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The Society of the Plastics Industry, Inc.

Facts & Figures

of the

U.S. Plastics Industry

1988 edition

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THE SOCIETY OF THE PLASTICS INDUSTRY, INC.

The Society of the Plastics Industry, Inc. is a member-run association dedicated to promoting and protecting continuing growth for the plastics industry in the United States. The Society represents more than 2,000 member companies.

SPI's 27 operating units and more than 200 committees have membership drawn from all segments of the industry - processors, resin and adjuvant suppliers, plastics distributors, machinery builders, and moldmakers. The Society serves as a federation of semi-autonomous, interrelated groups with a strong, common interest in the overall health of the plastics industry.

SPI serves as the "industry spokesman." It identifies and provides positive responses to misinformation and to potentially harmful regulations, bills, or court decisions by mobilizing pertinent facts and carrying out programs for timely and forceful action. At the same time, SPI works to prevent such damaging situations from occuring by building a positive understanding of the industry. The Society's service committees provide liaison with government agencies, code and regulatory groups, and many other associations.

SPI sponsors research projects in areas such as resource recovery, combustibility, and worker safety, at major private research organizations. The Society conducts numerous information programs, providing literature, surveys, reports, newsletters, and handbooks for industry and public use.

SPI sponsors one of the largest trade shows in the United States - the National Plastics Exposition, held every three years. The most recent show was held in June 1988 at McCormick Place in Chicago.

Incorporated in 1937, SPI has grown with the dynamic industry it represents. In addition to the Society's headquarters office at 1275 K Street, N.W., Suite 400, Washington, D.C. 20005, SPI has four section offices: Eastern Office, 1275 K Street, N.W., Suite 400, Washington, D.C. 20005; Midwestern Office, 2400 East Devon Avenue, Suite 301, Des Plaines, IL 60018; New England Office, Stetson Place, 541 Main Street, Weymouth, MA 02190; Western Office, Saddleback Square, Suite 124, 12440 Firestone Boulevard, Norwalk, CA 90650; plus a New York Office, 355 Lexington Avenue, New York, NY 10017.

SPI'S COMMITTEE ON RESIN STATISTICS

The SPI Committee on Resin Statistics is composed of 100 representatives from plastics resin producing companies, trade publications, industry-related professional organizations, and various agencies of the Federal Government. All members of the Committee are quite knowledgeable of the rapidly growing plastics industry and have a special interest in the development of marketing and economic data.

The Committee is responsible for the development and maintenance of a monthly report on the major plastics materials. This report shows monthly and cumulative data on production and sales & use (including captive operations) with percent change from the previous year. It is the only detailed monthly report on plastics materials now available. There are over one hundred producers participating in the monthly program and they are believed to represent about 95% of total U.S. plastics production. Many of the materials covered reflect 100% industry coverage. The data is compiled by Ernst & Whinney, nationally renowned Independent Public Accountants.

The Committee is actively involved with the various departments of the Federal Government (International Trade Commission, Department of Commerce, Bureau of the Census, Bureau of Labor Statistics, etc.) assisting them in the development and improvement of the plastics segments of their reports.

The Committee is also responsible for monitoring all resin data which appear in FACTS & FIGURES, thus assuring the most accurate and timely data.

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The Society of the Plastics Industry, Inc.

General Statistics

DEVELOPMENT OF TODAY'S PLASTICS

Today's plastics are one of the most used material on a volume basis in America's industrial and commercial life. The role of plastics is so broadly integrated in our own lifestyle that today there is virtually no product area where plastics do not make a major, irreplaceable contribution. Although the plastics industry in the United States is now in its second century, the most important developments have occurred since 1910. However, the roots of these modern develpoments go back not only to the research of cellulose nitrate by John Wesley Hyatt in the 1860's, but also to the plastic-like compositions used by man through the centuries.

ORIGIN OF PLASTICS

One can go as far back as the Old Testament to find references about natural materials used as fillers, adhesives, coatings, and the like. These materials were the precursors of what we call plastic materials today. Consequently, historians differ as to the exact date that the plastic industry began, and they will continue to do so since an exact year or even decade for the event is a matter of interpretation as to what constitutes a "plastic."

Certainly the history of the rubber industry has a bearing on plastics since ebonite, or hard rubber, discovered in 1851, was the first thermosetting material to be prepared and also the first material which involved a distinct chemical modification of a natural material. But ebonite was not exploited commercially for some years after its discovery and for that reason its historical importance has become somewhat blurred.

EUROPEAN DEVELOPMENTS

While the basic processes of rubber technology were developing, other important discoveries were taking place in Europe. Following work by Pelouze, Schonbein was able to establish conditions of controlled nitration of cellulose. The product soon became of interest as an explosive and in the manufacture of collodion, a cellulose solution in an alcohol-ether mixture. In the 1850's the English inventor Alexander Parkes observed that the solid residue left after the evaporation of the solvent of photographic collodion was a "hard, horny elastic and waterproof substance." In 1856 he patented the process of waterproofing woven fabrics by the use of such materials.

In 1862 the Great Exhibition was held in London. It was there that Parkes introduced a new material named for himself--Parkesine. Parkesine was obtained by dissolving cellulose nitrate in a minimum of solvent. The mixture was then put on a heated rolling machine from which some of the solvent was then removed. While still in the plastic state the material was then shaped by dies or pressure. In 1866 Parkes organized the Parkesine Company to manufacture products from his new material, but the company failed in 1868. This appears in part due to Parkes' attempt to reduce production costs which resulted in the production of inferior items.

One year after the failure of the Parkesine Company, an associate of Parkes, Daniel Spill, formed the Xylonite Company to manufacture products similar to Parkesine. Once again, economic failure resulted and Spill's company went bankrupt in 1874. Undaunted, Spill moved to a new site, established the Daniel Spill Company and continued production of his material, Xylonite.

FIRST PLASTICS IN THE U.S.

In the United States during the 1860's, someone else was experimenting with cellulose nitrate--John Wesley Hyatt. In 1865, Hyatt became involved in devising a method for producing billiard balls from materials other than Ivory. Originally using mixtures of cloth, ivory dust and shellac, in 1869 he patented the use of collodion for coating billiard balls. The patent came one year after his collodion material was introduced commerically.

John W. Hyatt and his brother Isaiah took out U.S. Patent 105,338 in 1870 for a process of producing a horn-like material using cellulose nitrate and camphor. Although Parkes and Spill had mentioned camphor in their work, it was the Hyatt brothers who recognized the value of camphor as a plasticizer for cellulose nitrate. In 1872, the term celluloid was coined by Isaiah Hyatt to describe the Hyatts' commerically successful product.

The validity of Hyatts' patents was challenged by Spill and a number of court actions took place between 1877 and 1884. In the final action, it was found that Spill had no claim on the Hyatt brothers, the judge ruling that the true inventor of the process was Parkes since he (Parkes) had mentioned the use of camphor in his patents. Thus, there was no restriction on the use of these processes and any company, including the Hyatts' Celluloid Manufacturing Company, was free to use them. After that decision, the Celluloid Manufacturing Company prospered, changed its name to the American Cellulose Chemical Corporation, and eventually was absorbed by the Celanese Corporation.

FORMALDEHYDE RESINS

Next to cellulose nitrate, the most important material in the early history of plastics was formaldehyde. Around 1897 there was a demand in German schools for a white chalkboard. Efforts to obtain such a product resulted in the discovery of casein plastics, produced by reacting casein (milk protein) with formaldehyde. The material soon became established under the trade names of Galalith and Erinoid, and today casein is still used by the button industry.

In 1899, Arthur Smith took out Brtitish Patent 16,275, the first dealing with phenol-formaldehyde resins, in this case for use as an ebonite substitute in electrical insulation. During the next decade, the phenol-formaldehyde reaction was investigated mainly for academic interest. In 1907, however, Leo Hendrik Baekeland discovered techniques of so controlling and modifying the reaction that useful products could be made from it. Thus phenolics were first fully synthetic resins to become commerically successful.

Prompted by the success of phenolic moldings, research began on reacting other materials, such as urea and thiourea, with formaldehyde. These materials were used in the manufacture of molding powders. Unlike phenolics, they could be molded into light-colored articles and they rapidly achieved commerical success. Today these urea-based resins are used for molding powders, adhesives, and textile and paper finishing while the related melamine-formaldehyde resins are used in decorative laminates.

GROWTH OF MODERN PLASTICS

Cellulose acetate, a thermoplastic, was developed about the same time as the urea-based resins. Similar in structure to cellulose nitrate, it was found to be safer in processing and use. Cellulose acetate was introduced as a molding compound in 1927.

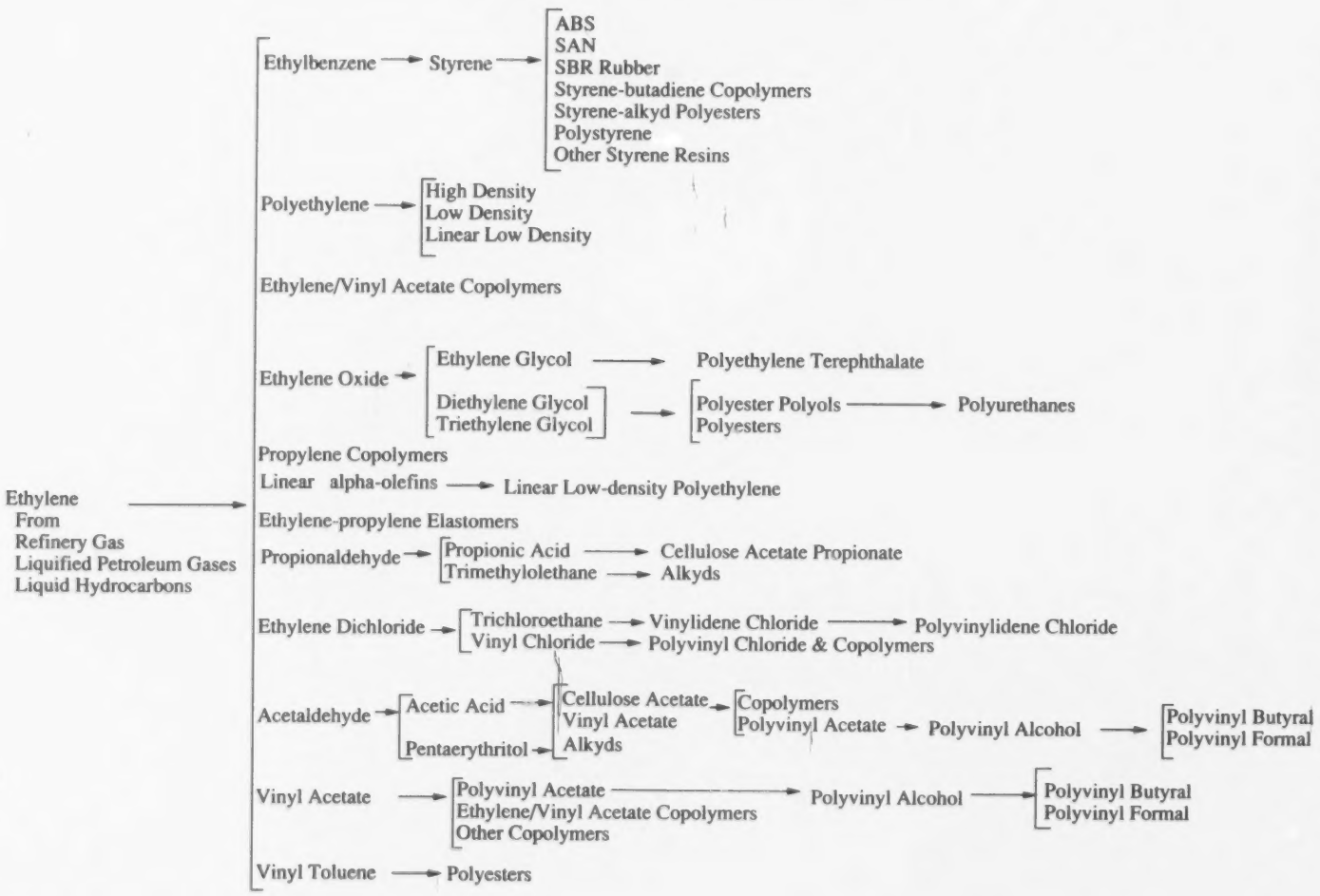
The period 1930-1940 saw the initial commercial development of today's major thermoplastics: polyvinyl chloride, low density polyethylene, polystyrene, and polymethyl methacrylate. The advent of the Second World War in 1939 brought plastics into great demand, largely as substitutes for materials in short supply, such as natural rubber. In the United States, the crash program leading to large-scale production of synthetic rubbers resulted in extensive research into the chemistry of polymer formation, and eventually, to the development of more plastic materials.

The first decade after World War II saw the development of high density polyethylene and polypropylene and the growth of the new plastics in many applications. Large-scale production of these materials reduced their cost dramatically. The new materials began to compete with the older plastics and even with the more traditional materials such as wood, paper, metal, glass and leather. Since that time, the demand for plastics has increased steadily so that plastics are now accepted by designers and engineers as basic materials along with the more traditional materials. The automotive industry, for instance, relies on plastics to reduce weight and thus increase mileage.

INTRODUCTION OF PLASTIC RESINS

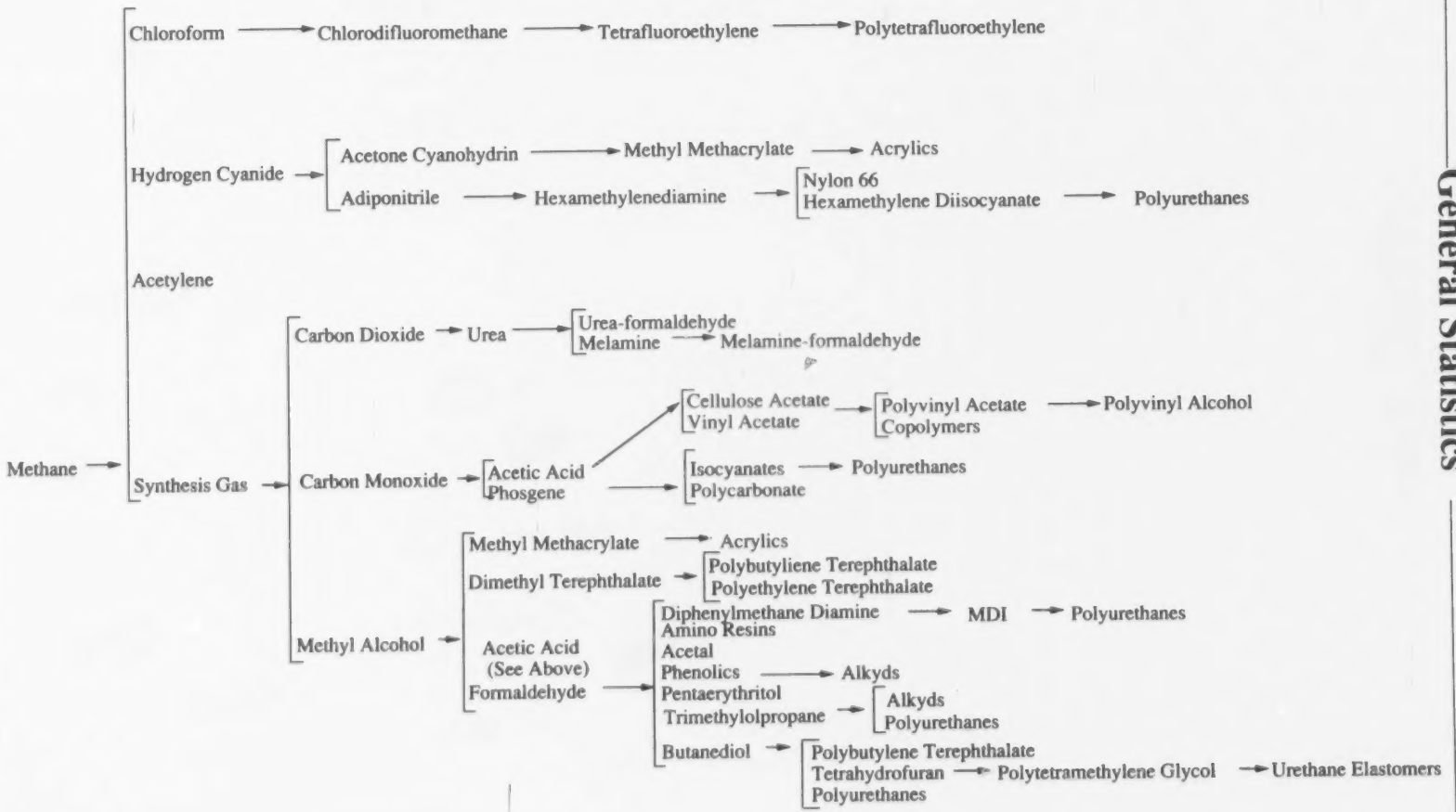
DATE	MATERIAL	EXAMPLE
1868	Cellulose Nitrate	Eye Glass Frames
1909	Phenol-Formadlehyde	Telephone Handset
1919	Casein	Knitting Needles
1926	Alkyd	Electrical Bases
1927	Cellulose Acetate	Tooth Brushes
1927	Polyvinyl Chloride	Wall Covering
1929	Urea-Formaldehyde	Lighting Fixtures
1935	Ethyl Cellulose	Flashlight Cases
1936	Acrylic	Brush Backs
1936	Polyvinyl Acetate	Flash Bulb Lining
1938	Cellulose Acetate Butyrate	Packaging
1938	Polystyrene	Housewares
1939	Nylon	Gears
1939	Polyvinylidene Chloride	Packaging Film
1939	Melamine-Formaldehyde	Tableware
1942	Unsaturated Polyester	Boat Hulls
1942	Low Density Polyethylene	Packaging
1943	Fluoropolymers	Industrial Gaskets
1943	Silicone	Motor Insulation
1945	Cellulose Propionate	Pens and Pencils
1947	Epoxy	Tools and Jigs
1948	Acrylonitrile-Butadiene-Styrene (ABS)	Luggage
1954	Styrene-Acrylonitrile (SAN)	Housewares
1954	Polyurethane	Foam Cushions
1956	Acetal	Automotive Parts
1957	High Density Polyethylene	Milk Bottles
1957	Polypropylene	Safety Helmets
1957	Polycarbonate	Appliance Parts
1959	Chlorinated Polyether	Valves and Fittings
1962	Phenoxy	Bottles
1964	Ionomer	Skin Packaging
1964	Polyphenylene Oxide	Battery Cases
1964	Polyimide	Bearings
1964	Ethylene-Vinyl Acetate	Adhesives and Coatings
1965	Polysulfone	Electrical/Electronic Parts
1970	Thermoplastic Polyester	Electrical/Electronic Parts
1973	Polybutylene	Piping
1973	Polyphenylene Sulfide	Telecommunications
1974	Polyethersulfone	Printed Circuit Boards
1975	Nitrile Barrier Resins	Non-food Packaging
1978	Linear Low Density Polyethylene	Extruded Film
1982	Polyetherimide	Electrical/Electronic Parts
1983	Polyetheretherketone	Wire and Cable
1984	Aromatic Copolyester	Electrical/Electronic Parts
1985	Liquid Crystal Polymers	Electrical/Electronic Parts

Plastics Derived From Ethylene



Source: Extracted in part from SRI International, Chemical Origins & Markets

Plastics Derived From Methane

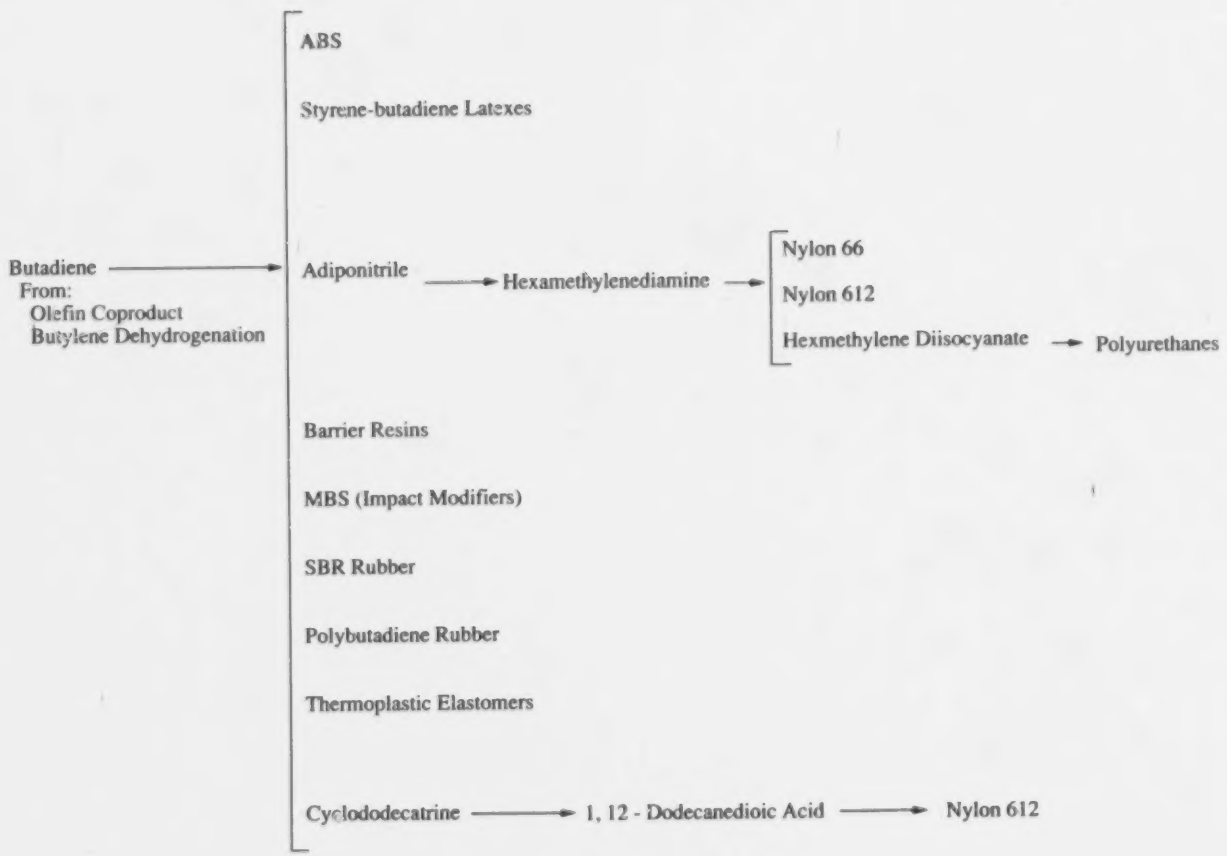


Source: Extracted in part from SRI International, Chemical Origins & Markets

Plastics Derived From Acetylene

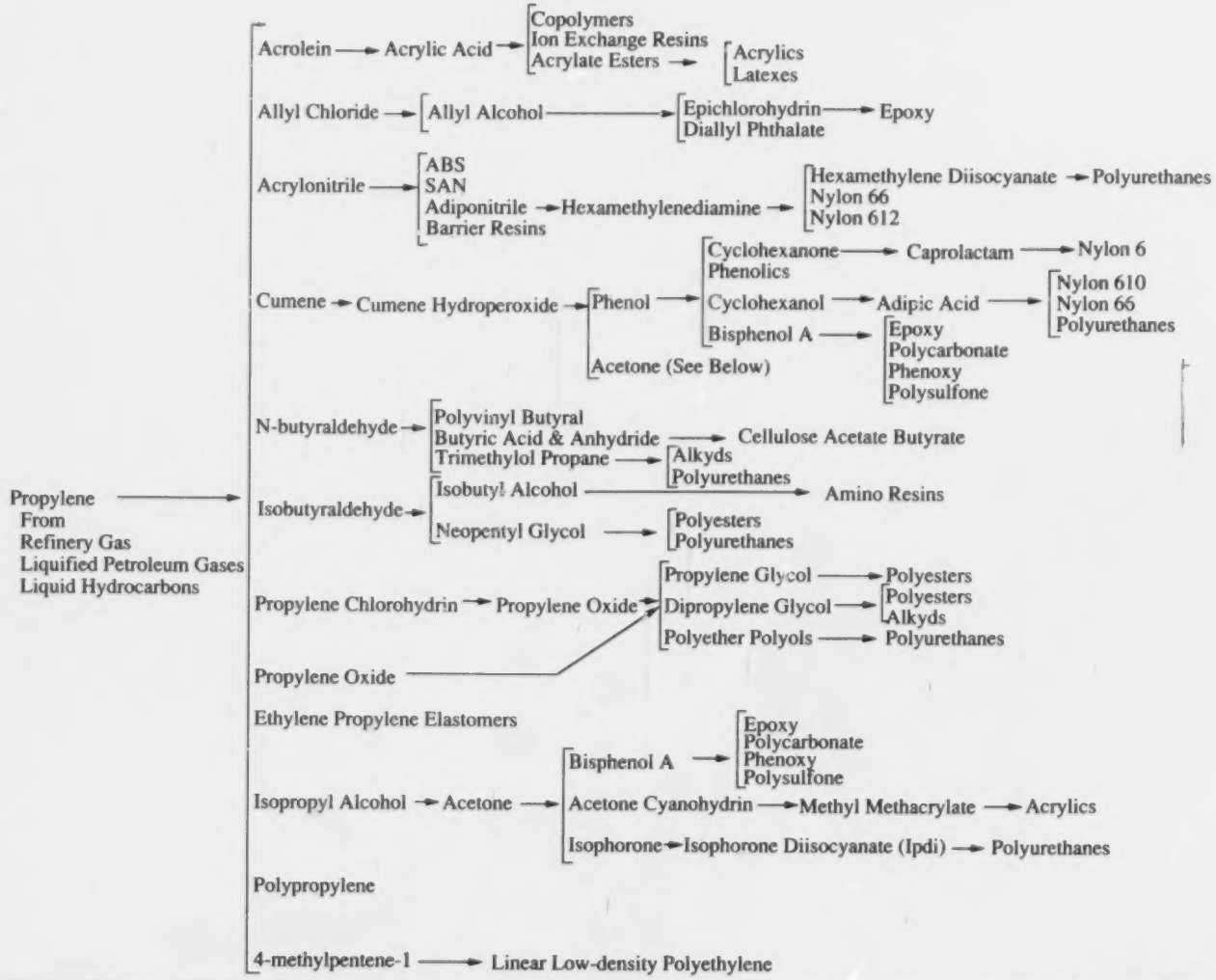
Source: Extracted in part from SRI International, Chemical Origins & Markets

Plastics Derived From Butadiene



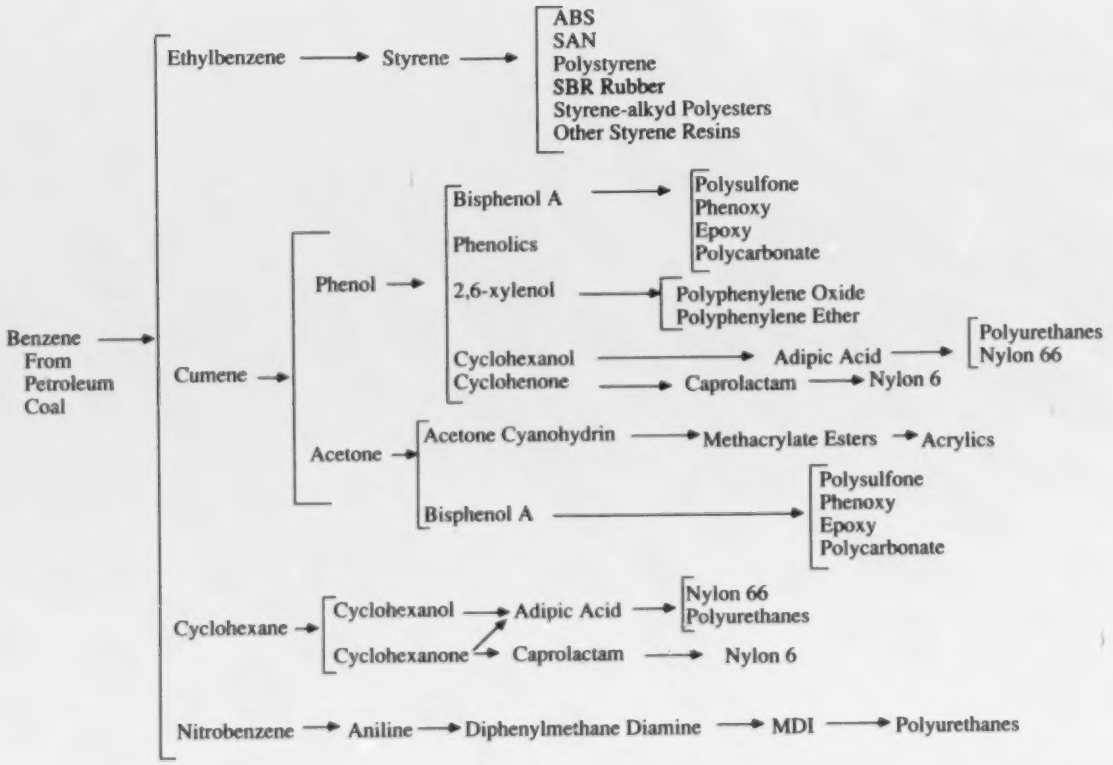
Source: Extracted in part from SRI International, Chemical Origins & Markets

Plastics Derived From Propylene



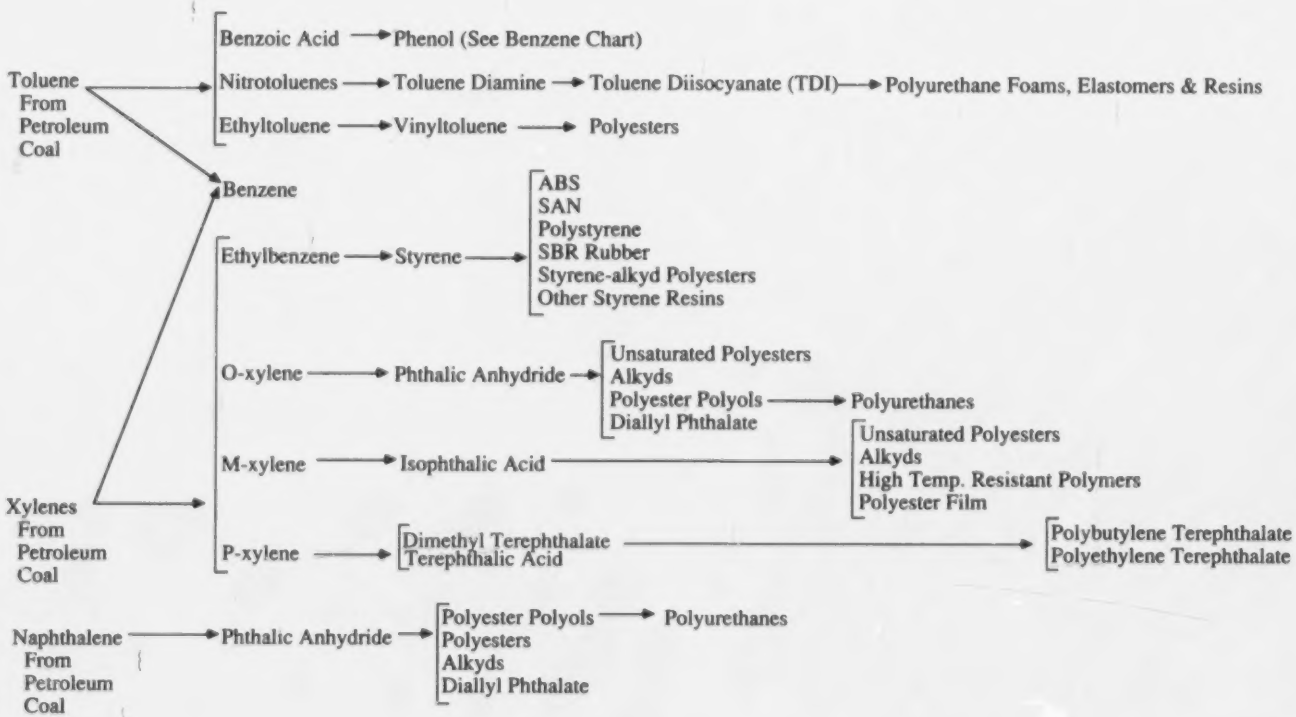
Source: Extracted in part from SRI International, Chemical Origins & Markets

Plastics Derived From Benzene



Source: Extracted in part from SRI International, Chemical Origins & Markets

Plastics Derived From Naphthalene, Toluene & Xylenes



Source: Extracted in part from SRI International, Chemical Origins & Markets

PLASTIC RESINS: 1962-1987

TOTAL U.S. PRODUCTION AND SALES & CAPTIVE USE *

(in millions of pounds)

YEAR	PRODUCTION (Including Polyurethane)	SALES & CAPTIVE USE (Including Polyurethane)
[a]1962	8,197	7,150
[b]1963	9,364	7,632
1964	10,525	8,847
1965	12,219	11,035
1966	14,199	11,726
1967	14,473	12,284
1968	17,231	15,396
1969	19,720	16,495
1970	20,056	17,494
[c]1971	21,161	19,813
1972	26,475	25,504
1973	29,213	28,719
1974	29,274	27,890
197.	22,828	22,278
1976	29,196	28,379
1977	33,948	32,771
1978	37,605	36,818
1979	41,577	40,607
1980	37,347	36,896
1981	39,867	38,801
1982	36,607	36,639
1983	42,777	42,212
1984	46,336	45,221
1985	47,946	47,470
[d]1986	50,849	50,452
1987	55,751	55,818

[a]U.S. Tariff Commission data used for 1962-1970. May exclude some captive use.
[b]Cellulosics not included through 1962. Included beginning in 1963.
[c]SPI data used for 1971-1987.
[d]1986-1987 includes SPI Estimates.

Compound Growth Rate

Years	Total Production	Sales & Captive Use
1962-1987	7.9%	8.5%
1972-1987	5.1%	5.3%
1977-1987	5.0%	5.4%
1982-1987	8.7%	8.7%
1986-1987	9.6%	10.6%

* Sales and Captive Use is Defined as Merchant Sales and Intra-Company Captive Use.

TOTAL U.S. PLASTICS BY RESIN

PRODUCTION and SALES & CAPTIVE USE

(in millions of pounds)

RESIN	1977		1978		1979		1980		1981	
	P	S&CU	P	S&CU	P	S&CU	P	S&CU	P	S&CU
Epoxy	261	278	299	316	361	332	315	319	336	332
Phenolic	1,458	1,400	1,617	1,543	1,781	1,732	1,499	1,517	2,333	2,375
Polyester	1,061	1,045	1,209	1,199	1,147	1,152	947	949	997	977
Urea	963	951	1,122	1,103	1,367	1,355	1,165	1,147	1,165	1,139
Melamine	200	203	202	196	200	192	167	166	179	175
Total Selected Thermosets	3,943	3,877	4,449	4,357	4,856	4,763	4,093	4,098	5,010	4,998
ABS	1,069	1,057	1,134	1,118	1,191	1,183	920	916	916	900
SAN	115	113	120	121	124	126	111	103	107	105
HDPE	3,562	3,557	4,201	4,165	5,010	4,893	4,405	4,394	4,695	4,683
LDPE	6,471	6,488	7,111	7,147	7,793	7,815	7,291	7,467	7,693	7,516
Nylon	254	250	275	278	327	315	274	271	312	288
Polypropylene	2,747	2,698	3,074	3,055	3,841	3,894	3,648	3,714	3,955	3,888
Polystyrene	3,446	3,557	3,823	3,870	4,005	3,997	3,521	3,518	3,621	3,604
PVC	5,253	5,232	5,723	5,810	6,119	6,138	5,470	5,407	5,707	5,601
Thermoplastic Polyester	--	--	--	--	--	--	503	511	610	581
Total Selected Thermoplastics	23,007	22,952	25,461	25,564	28,410	28,361	26,143	26,301	27,616	27,166
Total Selected Plastics	26,950	26,829	29,910	29,921	33,266	33,124	30,236	30,399	32,626	32,164
All Other Plastics*	6,998	5,942	7,695	6,897	8,311	7,483	7,111	6,497	7,241	6,637
Grand Total	**33,948**	**32,771**	**37,605**	**36,818**	**41,577**	**40,607**	**37,347**	**36,896**	**39,867**	**38,801**

COMPOUND GROWTH RATE 1977-1987

SALES & CAPTIVE USE

Epoxy	4.2%
Phenolic	**
Polyester	2.7%
Urea	3.7%
Melamine	-.3%
Total Selected Thermosetr	**
ABS	1.3%
SAN	1.2%
HDPE	8.7%
LDPE	4.0%
Nylon	7.2%
Polypropylene	9.6%
Polystyrene	3.2%
PVC	4.4%
Thermoplastic Polyester	NA
Total Selected Thermoplastics	5.9%

TOTAL U.S. PLASTICS BY RESIN

PRODUCTION and SALES & CAPTIVE USE (Cont'd)

(in millions of pounds)

1982		1983		1984		1985		1986		1987	
P	S&CU	P	S&CU	P	S&CU	P	S&CU	P	S&CU	P	S&CU
286	301	334	331	406	379	385	367	398	375	433	419
2,006	2,060	2,484	2,529	2,502	2,510	2,621	2,640	2,735	2,771	2,869	2,871
865	851	1,084	1,072	1,232	1,231	1,223	1,233	1,271	1,265	1,367	1,362
998	976	1,172	1,167	1,199	1,189	1,210	1,203	1,271	1,266	1,382	1,368
158	155	180	181	210	197	192	194	173	191	212	198
4,313	4,343	5,254	5,280	5,549	5,506	5,631	5,637	5,848	5,868	6,263	6,218
740	737	NA	NA	1,128	1,098	1,028	1,016	1,092	1,080	1,175	1,208
91	85	93	91	99	88	87	84	92	87	126	127
4,928	5,024	5,691	5,707	6,085	5,949	6,671	6,651	7,182	7,028	7,995	8,155
7,503	7,687	8,041	8,045	8,413	8,416	8,889	8,790	8,903	8,799	9,599	9,611
228	247	321	329	396	389	399	403	465	443	507	499
3,477	3,623	4,434	4,464	4,940	4,816	5,139	5,275	5,812	5,824	6,647	6,720
3,191	3,200	3,567	3,606	3,838	3,836	4,054	4,108	4,470	4,463	4,780	4,860
5,326	5,455	6,066	6,152	6,760	6,798	6,772	6,720	7,256	7,412	7,971	8,081
648	619	778	783	899	859	965	956	1,175	1,160	1,394	1,410
26,132	26,677	28,991	29,177	32,558	32,249	34,004	34,003	36,447	36,296	40,194	40,671
30,445	31,020	34,245	34,457	38,107	37,755	39,635	39,640	42,295	42,164	46,457	46,889
6,162	5,619	8,532	7,755	8,229	7,466	8,311	7,830	8,554	8,288	9,294	8,929
36,607	**36,639**	**42,777**	**42,212**	**46,336**	**45,221**	**47,946**	**47,470**	**50,849**	**50,452**	**55,751**	**55,818**

COMPOUND GROWTH RATE 1977-1987

SALES & CAPTIVE USE (Cont'd)

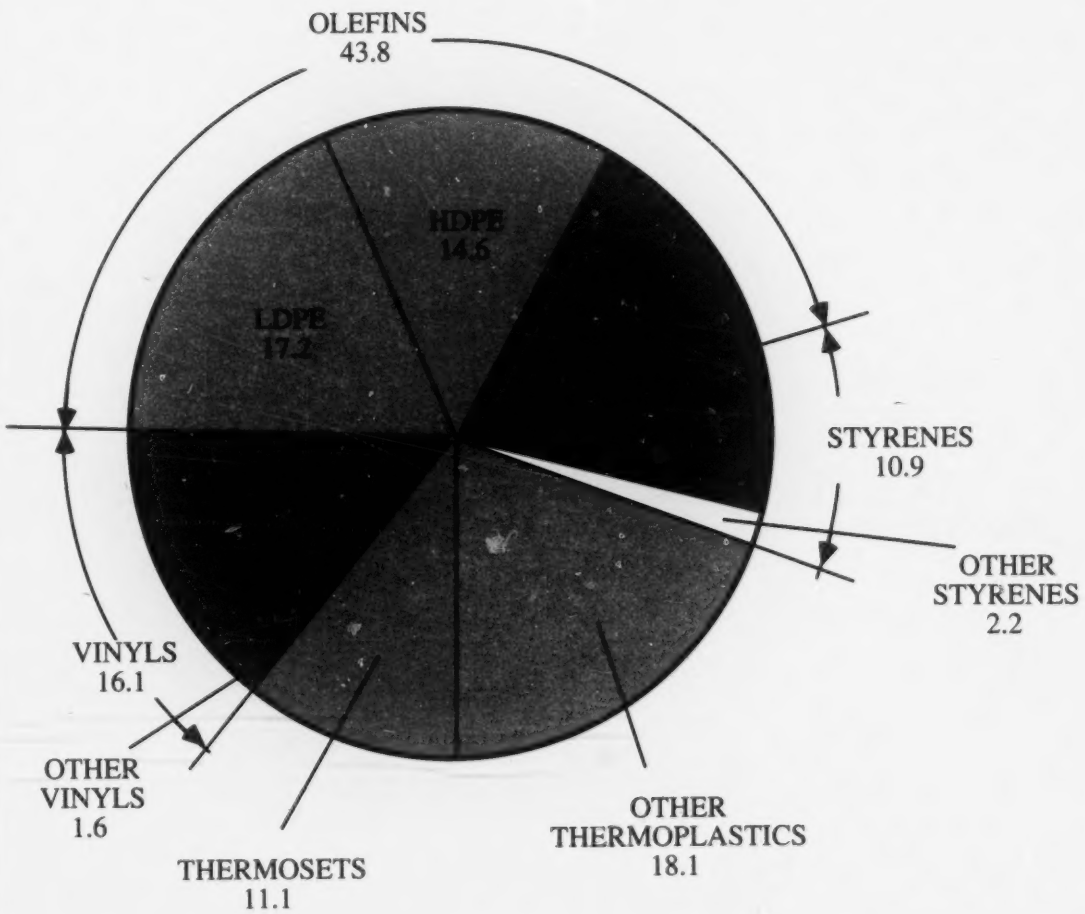
Total Selected Plastics	5.8%
All Other Plastics*	4.1%
Grand Total	**5.4%**

P = Production S = Sales & Captive Use NA = Not Available
**Not applicable since reporting on gross weight basis begun in 1981
*1986-1987 Includes SPI Estimates

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

PERCENTAGE DISTRIBUTION OF PLASTIC

SALES & CAPTIVE USE BY MATERIAL



PLASTIC RESINS

DOMESTIC MERCHANT SALES

(in millions of dollars and millions of pounds)

Resin	1987		1986		% Change	
	Net Dollar Value	Quantity	Net Dollar Value	Quantity	Net Dollar Value	Quantity
Low Density Polyethylene	$2,720	8,180	$2,131	7,526	27.6	8.7
Polyvinyl Chloride	2,143	6,533	1,740	6,323	23.2	3.3
High Density Polyethylene	2,162	7,002	1,636	6,102	32.2	14.7
Polystyrene	2,024	4,329	1,436	4,136	40.9	4.7
Polypropolene	1,670	4,498	1,290	3,886	29.5	15.7
ABS	784	1,037	690	951	13.6	9.0
Other Styrenes	751	1,075	644	1,078	16.6	-0.3
Unsaturated Polyester	765	1,306	644	1,185	18.8	10.2
Thermoplastic Polyester	815	1,187	689	1,021	18.3	16.3
Nylon	583	396	545	368	7 0	7.6
Phenolic	405	2,092	409	1,992	-1.0	5.0
Epoxy	415	344	362	305	14.6	12.8
Other Vinyls	142	110	172	104	-17.4	5.8
Urea	184	1,195	178	1,123	3.4	6.4
Melamine	178	186	134	153	32.8	21.6
SAN	48	90	41	64	17.1	40.6
Engineering Resins	1,006	739	1,015	580	-0.9	27.4
All Other (excluding PVAC & PU)	NA	NA	NA	NA	NA	NA
Total	**$16,795**	**40,299**	**$13,756**	**36,897**	**22.1**	**9.2**

Domestic merchant sales are quantities of sales excluding interplant transfers, captive consumption and exports.

Net dollar value represents the actual selling price after deductions for cash discounts, quantity discounts, returned goods and allowances, federal excise taxes, local taxes, and outgoing transportation (prepaid or otherwise) to warehouses or customers.

NA= Not Available

Source: SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

APPARENT U.S. CONSUMPTION OF SELECTED PLASTIC RESINS

Apparent consumption is calculated by adding imports to production then subtracting exports. It is an accurate measure of the quantity of material actually consumed in the United States.

For purposes of the table below, the production figures were taken from SPI's Monthly Statistical Report, as compiled by Ernst & Whinney. Both the import and export figures were taken from Bureau of the Census reports.

1987

(in millions of pounds)

RESIN	Production	Imports	Exports	Apparent Consumption	Import % Of Apparent Consumption
Low Density Polyethylene	9,599	749	1,035	9,313	8
High Density Polyethylene	7,995	70	901	7,164	1
PVC	7,971	130	393	7,708	2
Polypropylene	6,647	16	1,464	5,199	0
Polystyrene	4,780	19	142	4,657	0
Phenolic	2,869	47	57	2,857	2
Styrene Copolymers (inc. ABS)	2,530	146	316	2,360	6
Thermoplastic Polyester[a]	1,394	25	100	1,319	2
Urea	1,382	27	10	1,399	2
Unsaturated Polyester	1,367	7	40	1,334	1
Nylon	507	47	105	449	10
Epoxy	433	15	123	325	5
Melamine	212	5	14	203	2
Other Vinyls	212	31	64	179	17
1987 TOTAL	**47,898**	**1,334**	**4,764**	**44,468**	**3**
1986 Total	43,595 R	1,308 R	3,965 R	40,938 R	3
1985 Total	40,836	1,205	3,552	38,489	3
1984 Total	39,293	899	3,484	36,708	2
1983 Total	37,145	581	3,767	33,959	2
1982 Total	31,262	268	4,102	27,428	1
1981 Total	33,696	307	3,596	30,407	1
1980 Total	31,247	247	4,194	27,300	1
1979 Total	34,550	273	3,625	31,198	1
1978 Total	31,101	234	2,302	29,033	1
1977 Total	28,077	136	1,978	26,235	1

[a]Not included in total 1977-1979
R = Revision

Source: Production--SPI Monthly Statistical Report, as compiled by Ernst & Whinney
Imports--Bureau of the Census, IM 146
Exports--Bureau of the Census, EM 546

PLASTIC MATERIALS & RESINS

VALUE OF SHIPMENTS

(in millions of dollars)

VERSUS LARGEST CHEMICAL CATEGORIES	1984	1985	1986[1]	1987[2]	COMPOUND GROWTH RATE 1984-1987
Industrial Organic Chemicals	43,539	41,271	44,860	47,290	3.0%
Drugs	28,967	31,332	33,667	36,331	7.7
Plastic Materials & Resins	**20,774**	**20,262**	**20,659**	**23,854**	**4.8**
Industrial Inorganic Chemicals	18,007	18,183	18,341	18,570	1.0
Toilet Preparations	11,665	12,427	13,050	13,650	5.3
Paints and Allied Products	10,848	11,562	12,480	13,465	7.3
Soaps & Detergents	9,468	10,053	10,191	10,583	4.0
Fertilizers	8,116	7,654	5,437	6,455	-6.3
Polishes & Sanitation Goods	4,902	4,541	4,665	4,734	-1.0

VERSUS OTHER COMMODITIES	1984	1985	1986[1]	1987[2]	COMPOUND GROWTH RATE 1984-1987
Steel Mill Products	50,539	47,354	41,145	42,261	-6.0%
Paper and Board	37,544	35,944	39,817	43,440	5.0
Plastic Materials & Resins	**20,774**	**20,262**	**20,659**	**23,854**	**4.8**
Primary Aluminum	6,011	4,488	4,355	4,849	-7.0
Primary Copper	2,753	2,239	2,247	2,805	0.7
Leather Tanning & Finishing	1,814	1,643	1,715	2,043	4.2

1. Estimated Except for Exports - Imports
2. Estimated

Source: Department of Commerce Estimates

General Statistics

PLASTIC MATERIALS & RESINS

(SIC 2821)

(in millions of dollars except as noted)

	1984	1985	1986[1]	1987[2]	PERCENT CHANGE 1984-85	1985-86	1986-87
Industry Data							
Value of shipments[4]	20,776	20,262	20,659	23,854	-2.5	2.0	15.5
Value of shipments (1982$)	19,167	19,045	19,807	20,797	-0.6	4.0	5.0
Total employment (000)	54.2	55.4	55.1	55.5	2.2	-0.5	0.7
Production workers (000)	33.2	34.4	34.4	34.2	3.6	0.0	-0.6
Average hourly earnings ($)	13.33	14.33	14.87	15.27	7.5	3.8	2.7
Product Data							
Value of shipments[5]	22,730	21,574	21,827	26,404	-5.1	1.2	21.0
Value of shipments (1982$)	20,788	20,122	20,927	23,020	-3.2	4.0	10.0
Shipments price index (1982 = 100)[6]	109.3	107.2	95.1	NA	-2.0	11.3	NA
Trade Data							
Value of imports (ITA)[7]	725	772	872	895	6.5	13.0	2.6
Import/new supply ratio[8]	0.031	0.032	0.035	0.033	3.2	9.4	-0.1
Value of exports	2,655	2,547	2,805	2,878	-4.1	14.2	2.6
Export/shipment ratio	0.117	0.114	0.125	0.121	-2.6	9.6	-3.2

[1]Estimated except for exports and imports
[2]Estimated
[3]Forecast not included in this reporduction
[4]Value of all products and services sold by the Plastics Materials and Resins industry
[5]Value of products classified in the Plastics and Resins industry produced by all industries
[6]Developed by the Office of Industry Assessment, ITA
[7]Import data are developed by the chapter author
[8]New supply is the sum of product shipments plus imports
SOURCE: U.S. Department of Commerce: Bureau of the Census, Bureau of Economic Analysis, International Trade Administration (ITA). Estimates and forecasts by ITA.
NA = Not Available

MISCELLANEOUS PLASTIC PRODUCTS

(SIC 3079)

(in millions of dollars except as noted)

	1984	1985	1986[1]	1987[2]	PERCENT CHANGE 1984-85	1985-86	1986-87
Industry Data							
Value of shipments[4]	47,793	49,761	54,886	60,539	4.1	10.3	10.3
Value of shipments (1982$)	45,338	47,548	53,254	59,698	4.9	12.0	12.1
Total employment (000)	528	541	557	580	2.5	3.0	4.1
Production workers (000)	416	424	436	451	1.9	2.8	3.4
Average hourly earnings ($)	7.44	7.81	7.96	8.08	5.0	1.9	1.5
Product Data							
Value of shipments[5]	48,723	49,963	54,759	60,016	2.5	9.6	9.6
Value of shipments (1982$)	46,221	47,741	51,656	55,892	3.3	8.2	8.2
Shipments price index (1982 = 100)[6]	105.5	1,047	103.0	1.04	-0.8	-1.6	1.0
Trade Data							
Value of imports (ITA)[7]	1,808	2,100	2,435		16.2	16.0	
Value of exports[8]	2,094	2,000	2,050		-4.5	2.5	

[1]Estimated except for exports and imports
[2]Estimated
[3]Forecast not included in this reproduction
[4]Value of all products and services sold by the Plastics Materials and Resins industry
[5]Value of products classified in the Plastics and Resins industry produced by all industries
[6]Developed by the Office of Industry Assessment, ITA
[7]Import data are developed by the chapter author
[8]Export data are developed by the chapter author
SOURCE: U.S. Department of Commerce: Bureau of the Census, Bureau of Economic Analysis, International Trade Administration (ITA). Estimates and forecasts by ITA.

PROFILE OF 25 LARGEST MANUFACTURING INDUSTRIES

RELATIVE 1987RANK	SIC	INDUSTRY	1987 INDUSTRY SHIPMENTS (MIL. 1982$)
1	2911	Petroleum refining	$210,858
2	3711	Motor vehicles & car bodies	93,904
3	3714	Motor vehicle parts & accessories	56,250
4	**3079**	**Miscellaneous plastic products**	**50,165**
5	3662	Radio & TV communication equipment	46,900
6	3312	Steel mill products	43,750
7	2011	Meat packing plants	42,922
8	2869	Industrial organic chemicals	89,320
9	3674	Semiconductors & related devices	35,962
10	2752	Commercial printing & lithographic	35,807
11	3721	Aircraft	31,450
12	2621	Paper mills, except building paper	26,800
13	2711	Newspaper	23,017
14	**2821**	**Plastic materials & resins**	**21,954**
15	2026	Fluid milk	21,131
16	2834	Pharmaceutical preparations	20,545
17	3661	Telephone & telegraph apparatus	20,266
18	2086	Soft drinks	18,698
19	3728	Aircraft equipment, n.e.c.	18,350
20	3465	Automotive stampings	17,760
21	3861	Photographic equipment & supplies	17,300
22	3585	Refrigeration & heating equipment	16,500
23	3671	Guided missiles & space vehicles	16,232
24	3724	Aircraft engines & engine parts	14,850
25	2653	Corrugated & solid fiber boxes	13,475

Source: Department of Commerce

TOP 10 STATES OF THE PLASTICS INDUSTRY--1985*

NUMBER OF ESTABLISHMENTS[1]	
1. California	3,253
2. New York	1,520
3. Illinois	1,419
4. Ohio	1,399
5. New Jersey	1,265
6. Michigan	1,261
7. Texas	1,234
8. Pennsylvania	1,077
9. Massachusetts	959
10. Florida	909

NUMBER OF EMPLOYEES[2]	
1. California	121,200
2. Ohio	86,800
3. Illinois	76,500
4. New Jersey	66,800
5. New York	65,500
6. Pennsylvania	60,600
7. Michigan	58,400
8. Texas	56,200
9. Massachusetts	55,800
10. Indiana	45,900

VALUE OF SHIPMENTS[3] ($MILLION)	
1. Texas	$13,330
2. California	13,048
3. Ohio	11,072
4. Illinois	9,581
5. New Jersey	8,705
6. Pennsylvania	7,111
7. New York	6,794
8. Massachusetts	5,968
9. Michigan	5,590
10. Indiana	5,037

NEW CAPITAL EXPENDITURES ($MILLION)	
1. Texas	$702
2. California	609
3. Ohio	572
4. Illinois	448
5. Pennsylvania	298
6. New Jersey	264
7. Massachusetts	250
8. New York	240
9. North Carolina	203
10. Michigan	201

PAYROLL ($MILLION)	
1. California	$2,502
2. Ohio	1,977
3. Illinois	1,692
4. New Jersey	1,430
5. Texas	1,338
6. Pennsylvania	1,338
7. New York	1,292
8. Michigan	1,195
9. Massachusetts	1,088
10. Indiana	932

*The plastics industry includes establishments producing resins, machinery, fabricated products, and molds. To be updated in the 1989 issue.

[1]A company operating at more than one location is required to file a separate report for each location (establishment).

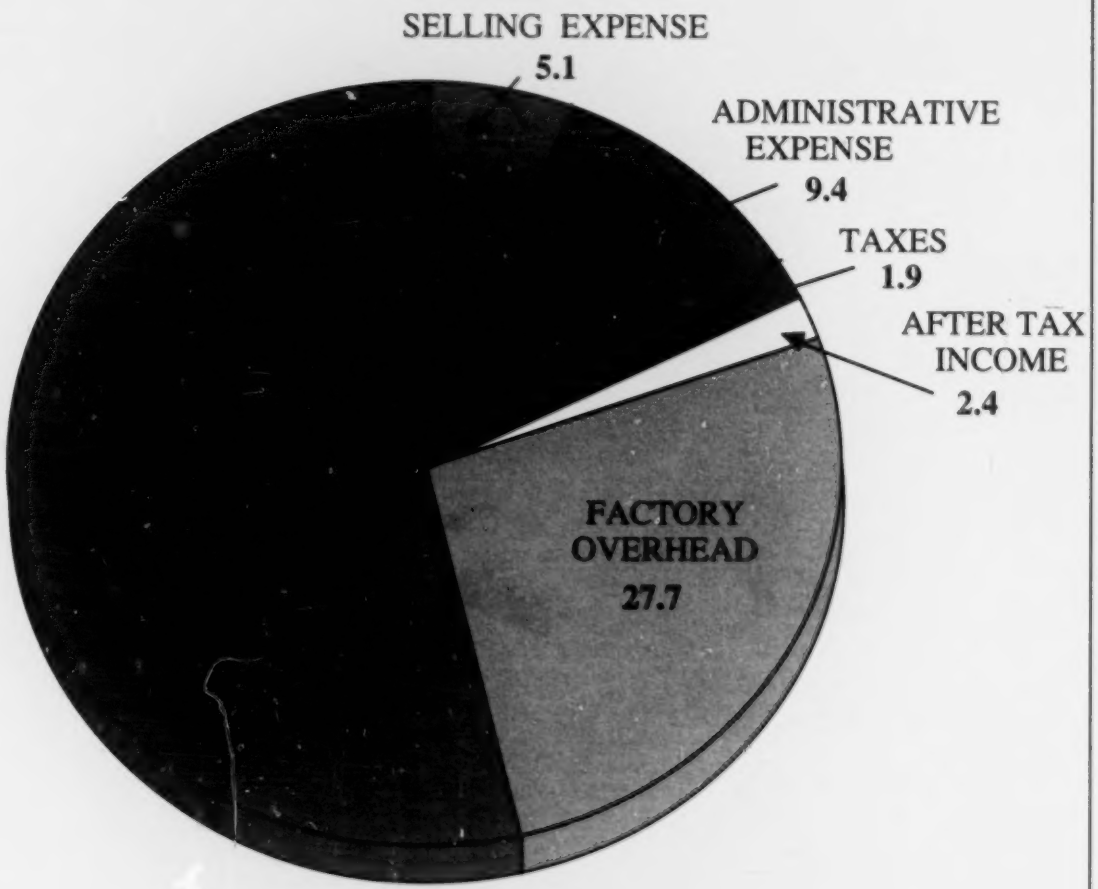
[2]Includes all employees, administrative and manufacturing.

[3]Covers the received or receivable net selling values, f.o.b. plant (exclusive of freight and taxes), of all products shipped, both primary and secondary, as well as all miscellaneous receipts, such as receipts for contract work performed for others, installation and repair, sales of scrap, and sale of products bought and resold without further processing.

Source: Department of Commerce, Bureau of the Census SPI estimates

PLASTICS PROCESSING COMPANIES*

SALES DOLLAR BREAKDOWN



* Includes custom processors and proprietary processors.

General Statistics

PLASTICS PROCESSING INDUSTRY

BY SALES GROUPS--1987

SALES LESS THAN $5 MILLION				SALES $5-10 MILLION		
Less Profitable*	Median	More Profitable**	Operating Statements	Less Profitable*	Median	More Profitable**
100.0	100.0	100.0	Net Sales	100.0	100.0	100.0
.9	.5	.9	Less Adjustments & Allowances	.8	1.1	.6
99.1	99.5	99.1	Net Sales	99.2	98.9	99.4
39.1	37.4	40.7	Direct Materials	39.2	38.5	39.4
8.8	15.8	9.6	Direct Labor	13.6	8.8	7.1
7.8	6.8	5.5	Indirect Labor	11.0	8.4	5.5
3.0	3.6	3.7	Utilities	3.0	4.8	3.3
3.3	2.7	3.0	Depreciation	4.5	3.3	2.4
28.8	16.9	11.9	Other Mfg. Expense	9.7	11.4	6.8
4.7	(.7)	.6	Net on Tool Transactions	(.4)	.1	.4
5.5	3.5	4.6	Selling Expenses	7.4	5.0	4.3
10.2	11.0	10.1	Administrative Expense	8.8	8.5	7.6
(12.1)	2.5	9.4	Operating Earnings	2.4	10.1	22.6
2.9	1.9	1.6	Other Income or (Expense)	1.7	3.2	2.5
(15.0)	.6	7.8	Profit Before Income Taxes	.7	6.9	20.1
(2.0)	.1	2.2	Income Taxes	.4	2.4	4.1
(13.0)	.5	5.6	PROFIT AFTER INCOME TAXES	.3	4.6	16.0
187.2	184.7	184.9	Sales as Percentage of Total Assets	181.8	185.6	185.8
			Balance Sheets			
7.2	3.8	18.0	Cash	3.6	11.6	3.5
23.0	22.1	16.7	Accounts & Notes Receivable	24.5	27.0	22.6
21.6	13.2	18.8	Inventory	19.4	22.0	19.6
7.6	1.8	4.9	Other Current Assets	3.3	2.8	19.2
59.4	40.9	58.4	CURRENT ASSETS	50.8	63.4	64.9
28.7	15.7	19.7	Land & Buildings, at Cost	25.0	18.2	18.0
10.3	4.5	3.7	Depreciation Reserve	5.6	6.5	13.6
44.5	63.3	57.9	Machinery & Equipment, at Cost	56.5	61.0	51.2
24.4	22.6	39.4	Depreciation Reserve	37.2	40.7	30.8
2.1	7.2	7.1	Other Long-Term Assets	10.5	4.6	10.3
100.0	100.0	100.0	TOTAL ASSETS	100.0	100.0	100.0
8.0	10.9	10.6	Current Portion of Term Debt	10.7	8.8	1.9
20.2	18.1	13.5	Notes Payable	17.6	9.9	.1
21.1	19.1	12.7	Accounts Payable, Trade	15.3	13.3	15.0
9.0	13.0	9.3	Other Payables & Accruals	11.4	11.3	8.9
58.3	61.1	46.1	CURRENT LIABILITIES	55.0	43.3	25.9
3.1	1.2	4.4	Other Long-Term Debt	6.7	3.3	5.9
61.4	62.3	50.5	TOTAL LIABILITIES	61.7	46.6	31.8
38.6	37.7	49.5	EQUITY (NET WORTH)	38.3	53.4	68.2
			Statistical Data			
9.2%	5.1%	22.9%	Percent Change in Sales, '86 vs '85	18.5%	17.0%	22.4%
45.9	31.2	49.3	Cost of Sales/Inventory	47.6	56.7	59.1
44.8	43.7	33.0	Average Collection Period	49.2	53.1	44.4
(28.1)%	1.1%	14.4%	Profit Before Income Taxes/Assets	1.3%	12.8%	37.3%
(63.0)%	2.5%	20.9%	Net Income/Equity	1.4%	16.0%	43.6%

*PBIT less than .6 percent
**PBIT more than .6 percent

*PBIT less than 6.9 percent
**PBIT more than 6.9 percent

Source: SPI Financial & Operating Ratios Survey No. 26-1987

PLASTICS PROCESSING INDUSTRY

BY SALES GROUPS--1987 (CONCLUDED)

Less Profitable*	Median	More Profitable**	
100.0	100.0	100.0	Net Sales
1.0	.9	.8	Less Adjustments & Allowances
99.0	99.1	99.2	Net Sales
44.9	45.9	39.4	Direct Materials
11.2	10.5	9.2	Direct Labor
9.8	7.9	10.0	Indirect Labor
2.9	3.8	3.0	Utilities
3.1	3.1	4.1	Depreciation
10.5	7.8	8.3	Other Mfg. Expense
.1	.2	.2	Net on Tool Transactions
5.7	4.5	4.6	Selling Expenses
7.2	6.1	5.4	Administrative Expense
3.6	10.3	15.0	Operating Earnings
2.1	2.9	1.8	Other Income or (Expense)
1.5	7.4	13.2	Profit Before Income Taxes
.8	2.7	4.2	Income Taxes
.7	4.7	9.0	PROFIT AFTER INCOME TAXES
177.7	185.4	186.1	Sales as Percentage of Total Assets
			Balance Sheets
2.7	2.6	3.7	Cash
23.3	24.9	25.0	Accounts & Notes Receivable
17.8	15.4	17.7	Inventory
3.7	3.1	3.5	Other Current Assets
47.5	46.0	49.9	CURRENT ASSETS
39.0	21.0	20.0	Land & Buildings, at Cost
10.7	6.5	6.3	Depreciation Reserve
55.3	48.0	71.9	Machinery & Equipment, at Cost
35.9	24.7	41.2	Depreciation Reserve
4.8	6.2	5.7	Other Long-Term Assets
100.0	100.0	100.0	TOTAL ASSETS
4.2	9.8	2.1	Current Portion of Term Debt
6.3	7.9	1.9	Notes Payable
14.9	16.4	11.6	Accounts Payable, Trade
8.9	13.0	10.1	Other Payables & Accruals
34.3	47.1	25.7	CURRENT LIABILITIES
18.6	10.4	13.0	Other Long-Term Debt
52.9	57.5	38.7	TOTAL LIABILITIES
47.1	42.5	61.3	EQUITY (NET WORTH)
			Statistical Data
16.4%	13.4%	12.3%	Percent Change in Sales, '86 vs '85
43.8	38.4	46.4	Cost of Sales/Inventory
47.9	44.0	49.0	Average Collection Period
2.7%	13.7%	24.6%	Profit Before Income Taxes/Assets
2.6%	20.5%	27.3%	Net Income/Equity

*PBIT less than 7.4 percent **PBIT more than 7.4 percent

Source: SPI Financial & Operating Ratios Survey No. 26-1987

Major Markets

CATEGORIES

The primary product groups for each Major Market category are listed below:

A. TRANSPORTATION

Motor Vehicles and Parts: including autos, trucks, buses, motorcycles, and bicycles.
All Other: including railroad equipment, travel trailers, campers, golf carts, snowmobiles, aircraft, military vehicles, ships, boats and recreational vehicles.

B. PACKAGING

Bottles, Jars, Vials
Food Containers: excluding disposable cups
Flexible Packaging: including household and institutional refuse bags and film
All Other: including tubes, tape, strapping, drums, caps, baskets, trays, boxes, pallets, shipping crates, pails, buckets, shipping cases, blister and bubble containers.

C. BUILDING AND CONSTRUCTION

Pipe, Conduit and Fittings: including drainage, irrigation, plumbing fixtures, and septic tanks
Building Material for all Structures: including siding, flooring, and insulation materials
All Other: including panels, doors, windows, skylights, bathroom units, gratings and railings.

D. ELECTRICAL/ELECTRONIC

Home and Industrial Appliances: including electrical industrial equipment, wire and cable coverings, communications equipment
Electronic Components: including resistors, magnetic tape, records, and batteries.

E. FURNITURE AND FURNISHINGS

Rigid and Flexible Types: including household and office furniture, bedding, carpets, rugs, backing, curtains, blinds, awnings, lamps, picture frames, and wall coverings.

F. CONSUMER AND INSTITUTIONAL PRODUCTS

Disposable Food Serviceware: including disposable cups
Dinner and Kitchenware: including picnicware
Toys and Sportings Goods
Health Care and Medical Products: including laboratory supplies
Hobby and Graphic Arts Supplies: including photographic equipment and supplies
All Other: including footwear, luggage, buttons, lawn & garden tools, signs & displays, and credit cards.

Major Markets

G. INDUSTRIAL/MACHINERY

All Types: including engine and turbine parts, farm and garden machinery, construction and related equipment, machine tools, ordnance and firearms, and chemical process equipment.

H. ADHESIVES/INKS/COATINGS

Adhesives and Sealants
All Other: including printing ink, magnet wire enamels, core binders, foundry facings, paper coating and glazing, paints, varnishes, and enamels.

I. RESELLERS/COMPOUNDERS

Sales of Resins Sold to Resellers, Compounders, Converters
Unclassified Sales: including calenderers whose end-use markets cannot be ascertained by the resin supplies, or resin that cannot be classified under any of the Major Market categories listed above.

J. EXPORTS

Sales of Plastic Resin exported from the U.S.

Major Markets

1987

The 1987 data reflect major market plastics resins sales and captive use data compiled by Ernst & Whinney with consumption data being reported by individual resin. The plastics resins categories included in this study are:

THERMOSETS

Epoxy
Polyester, Unsaturated
Urea and Melamine
Phenolic
All Other Thermosets

THERMOPLASTICS

Low Density Polyethylene
High Density Polyethylene
Polypropylene
Acrylonitrile-Butadiene-Styrene (ABS) and Styrene-Acrylonitrile (SAN)
Styrene Butadiene Latexes (SBL), and Other Styrene Based Latexes (OSBL), and Other Styrene Based Polymers (OSBP)
Nylon
Polyvinyl Chloride
Thermoplastic Polyester
All Other Thermoplastics

TOTAL RESIN SALES & CAPTIVE USE

BY MAJOR MARKET*

(millions of pounds, dry weight basis)

MAJOR MARKET	1983	1984	1985	1986	1987
Transportation	1,896	2,109	1,989	1,988	2,029
Packaging	11,813	12,398	12,774	13,267	15,234
Building and Construction	8,552	9,691	10,038	10,085	11,285
Electrical/Electronic	2,514	2,757	2,659	2,609	2,779
Furniture and Furnishings	2,007	2,117	2,107	2,191	2,235
Consumer and Institutional	3,816	3,986	3,975	4,123	5,063
Industrial/Machinery	318	400	364	361	332
Adhesives/Inks/Coatings	1,800	1,993	2,142	1,638	1,797
All Other	3,636	4,080	5,122	4,555	4,665
Exports	4,150	3,796	4,170	4,206	4,593
Total	**40,502**	**43,327**	**45,340**	**45,023**	**50,012**

*Note: All figures exclude polyurethane

Major Markets

COMPARATIVE PERCENTAGE DISTRIBUTION

BY MAJOR MARKET

MAJOR MARKET	1983	1984	1985	1986	1987
Transportation	4.7%	4.9%	4.4%	4.4%	4.1%
Packaging	29.2	28.6	28.2	29.5	30.4
Building and Construction	21.1	22.4	22.1	22.4	22.6
Electrical/Electronic	6.2	6.4	5.9	5.8	5.6
Furniture and Furnishings	5.0	4.9	4.7	4.9	4.5
Consumer and Institutional	9.4	9.2	8.8	9.2	10.0
Industrial/Machinery	0.8	0.8	0.8	0.8	0.7
Adhesives/Inks/Coatings	4.4	4.6	4.7	3.6	3.6
All Other	9.0	9.4	11.2	10.1	9.3
Exports	10.2	8.8	9.2	9.3	9.2
Total	100.0%	100.0%	100.0%	100.0%	100.0%

PERCENTAGE CHANGE IN SALES AND USE

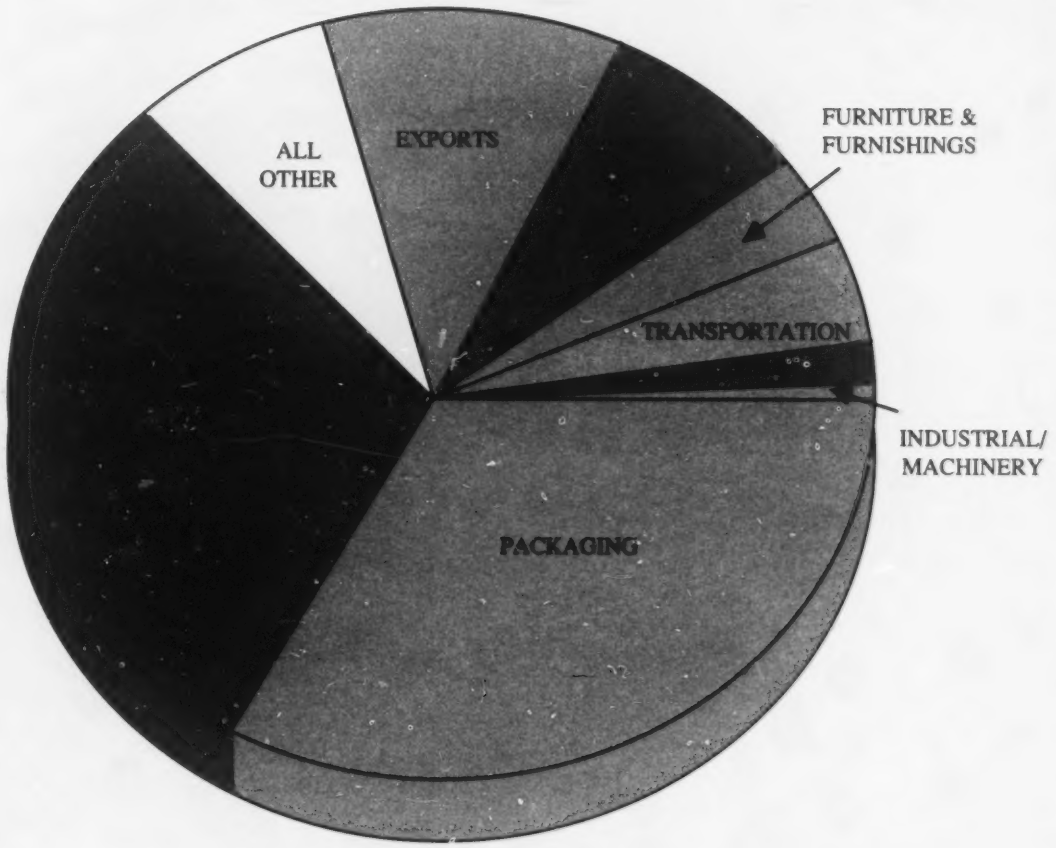
BY MAJOR MARKET

MAJOR MARKET	% CHANGE 1987/1986	% CHANGE 1986/1985
Transportation	2.1%	-0.1%
Packaging	14.8	3.9
Building and Construction	11.9	0.5
Electrical/Electronic	6.5	-1.9
Furniture and Furnishings	2.0	4.0
Consumer and Institutional	22.8	3.7
Industrial/Machinery	-8.0	-0.8
Adhesives/Inks/Coatings*	9.7	-23.5
All Other	2.4	-11.1
Exports	9.2	0.9
Total*	11.1%	-0.7%

* % change approximate, due to reporting changes in 1986

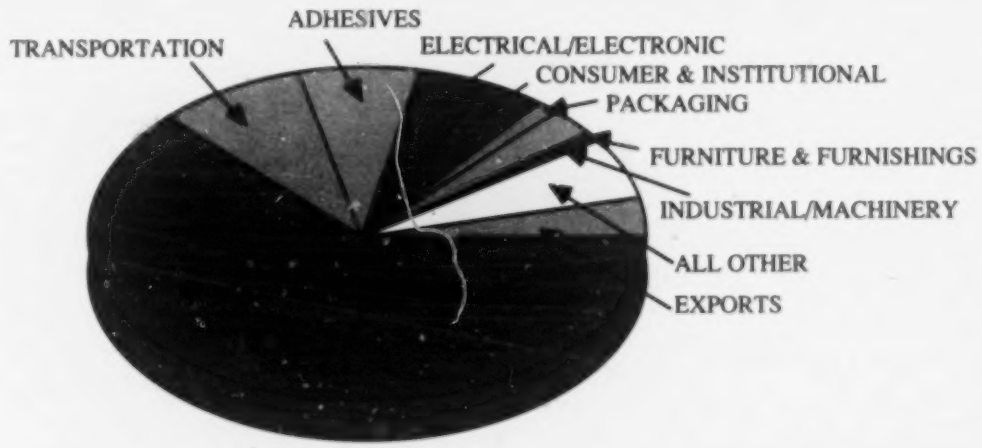
1987 DISTRIBUTION OF PLASTIC RESIN SALES & CAPTIVE USE BY MAJOR MARKET

ALL RESINS

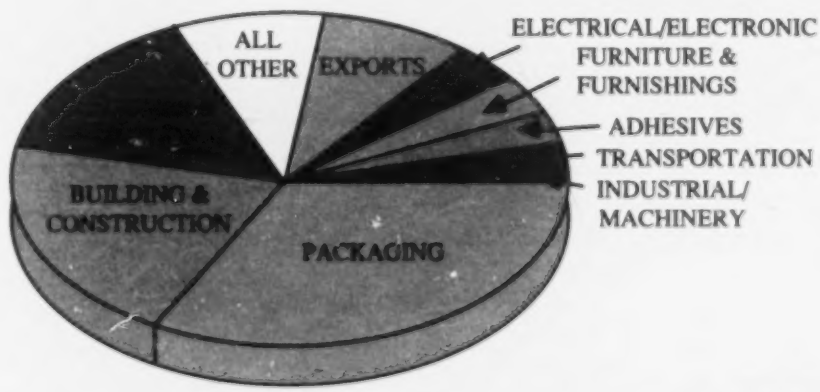


1987 DISTRIBUTION OF PLASTIC RESIN SALES & CAPTIVE USE BY MAJOR MARKET

THERMOSET RESINS



THERMOPLASTIC RESINS



Major Markets

1987 PLASTIC RESINS SALES & CAPTIVE USE

TOTAL THERMOSETS AND THERMOPLASTICS

(Millions of Pounds, Dry Weight Basis)^1

MARKET	TOTAL THERMOSETS		TOTAL THERMOPLASTICS		GRAND TOTAL	
	Quantity	Percent Of Total	Quantity	Percent Of Total	Quantity	Percent Of Total
TRANSPORTATION, TOTAL	**555**	**8.9**	**1,474**	**3.4**	**2,029**	**4.1**
Motor Vehicles and Parts	195	3.1	1,382	3.2	1,577	3.2
Ships, Boats and Recreational Vehicles	327	5.3	59	0.1	386	0.8
All Other Transportation Equipment	33	0.5	33	0.1	66	0.1
PACKAGING, TOTAL	**56**	**0.9**	**15,178**	**34.6**	**15,234**	**30.4**
Bottles, Jars, Vials	D		2,862	6.5	D	
Food Containers (Excluding Disposable Cups)	D		2,587	5.9	D	
Flexible Packaging - (Bags, Liners, Etc.)	D		6,135	14.0	D	
Household and Institutional Refuse Bags & Film	D		2,459	5.6	D	
All Other Flexible Packaging	D		3,676	8.4	D	
All Other Packaging	41	0.7	3,594	8.2	3,635	7.3
BUILDING AND CONSTRUCTION, TOTAL	**4,175**	**67.1**	**7,110**	**16.2**	**11,285**	**22.6**
Pipe, Conduit and Fittings	96	1.5	4,399	10.1	4,495	9.0
Building Materials for All Structures	3,243	52.2	2,046	4.6	5,289	10.6
Siding, Siding Accessories & Structural Panels for Siding	662	10.7	631	1.4	1,293	2.6
Flooring	588	9.5	358	0.8	946	1.9
Insulation Material	735	11.8	517	1.2	1,252	2.5
All Other Building Materials for All Structures	1,258	20.2	540	1.2	1,798	3.6
All Other Building and Construction	836	13.4	665	1.5	1,501	3.0
ELECTRICAL/ELECTRONIC, TOTAL	**286**	**4.6**	**2,493**	**5.8**	**2,779**	**5.6**
Home and Industrial Appliances	85	1.4	771	1.8	856	1.7
Communications Equipment	18	0.3	77	0.2	95	0.2
Electric Equipment Combined with Electronic Components	183	2.9	551	1.3	734	1.5
Storage Batteries	D		243	0.6	D	
Wire and Cable	D		851	1.9	D	
FURNITURE AND FURNISHINGS, TOTAL	**129**	**2.1**	**2,106**	**4.8**	**2,235**	**4.5**
Rigid Furniture	113	1.8	124	0.3	237	0.5
Flexible Furniture	D		103	0.2	D	
Carpet and Carpet Components	D		1,261	2.9	D	
Other Textiles and Furnishings	14	0.2	618	1.4	632	1.3
CONSUMER AND INSTITUTIONAL PRODUCTS, TOTAL	**254**	**4.1**	**4,809**	**10.9**	**5,063**	**10.0**
Disposable Food Serviceware (Includes Disposable Cups)	D		1,271	2.9	D	
Health Care and Medical Products	D		849	1.9	D	
Toys and Sporting Goods	49	0.8	436	1.0	485	1.0
Hobby and Graphic Arts Supplies	D		209	0.5	D	
All Other Consumer and Institutional Products	82	1.3	2,044	4.6	2,126	4.3
INDUSTRIAL/MACHINERY, TOTAL	**17**	**0.3**	**315**	**0.7**	**332**	**0.7**
ADHESIVES/INKS/COATINGS, TOTAL	**337**	**5.4**	**1,460**	**3.4**	**1,797**	**3.6**
Adhesives and Sealants	80	1.3	511	1.2	591	1.2
All Other Inks and Coatings	257	4.1	949	2.2	1,206	2.4
ALL OTHER, TOTAL	**306**	**4.9**	**4,359**	**9.9**	**4,665**	**9.3**
EXPORTS, TOTAL	**103**	**1.7**	**4,490**	**10.3**	**4,593**	**9.2**
GRAND TOTAL	**6,218**	**100.0**	**43,794**	**100.0**	**50,012**	**100.0**

^1 - Phenolic is on a Gross Weight Basis

D - Disclosure

- Due to disclosure Urea & Melamine Exports are included in All Other

Compiled By Ernst & Whinney, Washington, D.C., for SPI's Committee on Resin Statistics (CRS)

Major Markets

1987 PLASTIC RESINS SALES & CAPTIVE USE

THERMOSETS

(Millions of Pounds, Dry Weight Basis)

MARKET	EPOXY		POLYESTER		UREA & MELAMINE	
	Quantity	Percent Of Total	Quantity	Percent Of Total	Quantity	Percent Of Total
TRANSPORTATION, TOTAL	**D**		**472**	**34.6**	**D**	
Motor Vehicles and Parts	D		131	9.6	D	
Ships, Boats and Recreational Vehicles	D		316	23.2	--	--
All Other Transportation Equipment	D		25	1.8	--	--
PACKAGING, TOTAL	**6**	**1.4**	**D**		**31**	**2.0**
Bottles, Jars, Vials	D		--	--	--	--
Food Containers (Excluding Disposable Cups)	D		D		D	
Flexible Packaging - (Bags, Liners, Etc.)	D		--	--	D	
Household and Institutional Refuse Bags & Film	D		--	--	D	
All Other Flexible Packaging	D		--	--	--	--
All Other Packaging	D		D		D	
BUILDING AND CONSTRUCTION, TOTAL	**47**	**11.2**	**541**	**39.7**	**1,193**	**76.2**
Pipe, Conduit and Fittings	D		74	5.4	--	--
Building Materials for All Structures	21	5.0	214	15.7	D	
Siding, Siding Accessories & Structural Panels for Siding	D		93	6.8	D	
Flooring	13	3.1	D		D	
Insulation Material	D		D		D	
All Other Building Materials for All Structures	D		107	7.9	486	31.0
All Other Building and Construction	D		254	18.6	D	
ELECTRICAL/ELECTRONIC, TOTAL	**D**		**48**	**3.5**	**D**	
Home and Industrial Appliances	D		D		--	--
Communications Equipment	D		D		--	--
Electric Equipment Combined with Electronic Components	74	17.7	D		D	
Storage Batteries	D		--	--	--	--
Wire and Cable	D		--	--	--	--
FURNITURE AND FURNISHINGS, TOTAL	**D**		**22**	**1.6**	**38**	**2.4**
Rigid Furniture	D		9	0.7	D	
Flexible Furniture	D		D		D	
Carpet and Carpet Components	D		--	--	--	--
Other Textiles and Furnishings	D		D		--	--
CONSUMER AND INSTITUTIONAL PRODUCTS, TOTAL	**D**		**98**	**7.2**	**D**	
Disposable Food Serviceware (Includes Disposable Cups)	D		D		D	
Health Care and Medical Products	D		--	--	--	--
Toys and Sporting Goods	D		D		--	--
Hobby and Graphic Arts Supplies	D		D		--	--
All Other Consumer and Institutional Products	D		46	3.4	D	
INDUSTRIAL/MACHINERY, TOTAL	**6**	**1.4**	**D**		--	--
ADHESIVES/INKS/COATINGS, TOTAL	**148**	**35.4**	**D**		**D**	
Adhesives and Sealants	22	5.3	D		D	
All Other Inks and Coatings	126	30.1	D		D	
ALL OTHER, TOTAL	**24**	**5.7**	**79**	**5.8**	**93**	**5.9**
EXPORTS, TOTAL	**75**	**17.9**	**10**	**0.7**	**D(#)**	
GRAND TOTAL	**419**	**100.0**	**1,362**	**100.0**	**1,566**	**100.0**

- Due to disclosure Urea & Melamine Exports are included in All Other

D - Disclosure

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Major Markets

1987 PLASTIC RESINS SALES & CAPTIVE USE

THERMOSETS / THERMOPLASTICS

(Millions of Pounds, Dry Weight Basis)^1

MARKET	PHENOLIC		LOW DENSITY PE		HIGH DENSITY PE	
	Quantity	Percent Of Total	Quantity	Percent Of Total	Quantity	Percent Of Total
TRANSPORTATION, TOTAL	**63**	**2.2**	**D**		**213**	**2.6**
Motor Vehicles and Parts	D		D		205	2.5
Ships, Boats and Recreational Vehicles	D		D		D	
All Other Transportation Equipment	D		D		D	
PACKAGING, TOTAL	**D**	--	**6,161**	**64.2**	**4,325**	**53.0**
Bottles, Jars, Vials	--	--	47	0.5	1,568	19.2
Food Containers (Excluding Disposable Cups)	--	--	537	5.6	871	10.7
Flexible Packaging - (Bags, Liners, Etc.)	--	--	4,637	48.3	598	7.3
Household and Institutional Refuse Bags & Film	--	--	2,151	22.4	67	0.8
All Other Flexible Packaging	--	--	2,486	25.9	531	6.5
All Other Packaging	D	--	940	9.8	1,288	15.8
BUILDING AND CONSTRUCTION, TOTAL	**2,394**	**83.4**	**377**	**3.9**	**775**	**9.5**
Pipe, Conduit and Fittings	D		D		609	7.5
Building Materials for All Structures	D		202	2.1	D	
Siding, Siding Accessories & Structural Panels for Siding	D		--	--	D	
Flooring	403	14.0	D		--	--
Insulation Material	698	24.3	D		D	
All Other Building Materials for All Structures	D		D		D	
All Other Building and Construction	D		D		D	
ELECTRICAL/ELECTRONIC, TOTAL	**122**	**4.3**	**420**	**4.4**	**138**	**1.7**
Home and Industrial Appliances	68	2.4	D		D	
Communications Equipment	16	0.6	--	--	--	--
Electric Equipment Combined with Electronic Components	38	1.3	D		D	
Storage Batteries	--	--	--	--	D	
Wire and Cable	--	--	D		131	1.6
FURNITURE AND FURNISHINGS, TOTAL	**D**		**41**	**0.4**	**D**	
Rigid Furniture	D		D		D	
Flexible Furniture	--	--	--	--	--	--
Carpet and Carpet Components	--	--	25	0.3	--	--
Other Textiles and Furnishings	--	--	D		D	
CONSUMER AND INSTITUTIONAL PRODUCTS, TOTAL	**D**		**610**	**6.3**	**896**	**11.0**
Disposable Food Serviceware (Includes Disposable Cups)	D		204	2.1	D	
Health Care and Medical Products	--	--	77	0.8	D	
Toys and Sporting Goods	--	--	53	0.6	86	1.1
Hobby and Graphic Arts Supplies	--	--	D		D	
All Other Consumer and Institutional Products	D		D		659	8.1
INDUSTRIAL/MACHINERY, TOTAL	**D**		**D**		**159**	**1.9**
ADHESIVES/INKS/COATINGS, TOTAL	**67**	**2.3**	**337**	**3.5**	**D**	
Adhesives and Sealants	D		D		--	--
All Other Inks and Coatings	D		D		D	
ALL OTHER, TOTAL	**110**	**3.8**	**631**	**6.6**	**732**	**9.0**
EXPORTS, TOTAL	**18**	**0.6**	**1,003**	**10.4**	**883**	**10.8**
GRAND TOTAL	**2,871**	**100.0**	**9,611**	**100.0**	**8,155**	**100.0**

^1 = Phenolic is on a Gross Weight Basis

D - Disclosure

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Major Markets

1987 PLASTIC RESINS SALES & CAPTIVE USE

THERMOPLASTICS

(Millions of Pounds, Dry Weight Basis)

MARKET	POLYPROPYLENE		ABS & SAN		POLYSTYRENE	
	Quantity	Percent Of Total	Quantity	Percent Of Total	Quantity	Percent Of Total
TRANSPORTATION, TOTAL	**276**	**4.1**	**D**		**D**	
Motor Vehicles and Parts	D		D		D	
Ships, Boats and Recreational Vehicles	D		D		D	
All Other Transportation Equipment	D		--	--	D	
PACKAGING, TOTAL	**1,450**	**21.5**	**D**		**1,421**	**29.2**
Bottles, Jars, Vials	117	1.7	D		69	1.4
Food Containers (Excluding Disposable Cups)	168	2.5	--	--	915	18.8
Flexible Packaging - (Bags, Liners, Etc.)	501	7.4	D		36	0.7
Household and Institutional Refuse Bags & Film	163	2.4	D		--	--
All Other Flexible Packaging	338	5.0	--	--	36	0.7
All Other Packaging	664	9.9	--	--	401	8.3
BUILDING AND CONSTRUCTION, TOTAL	**34**	**0.5**	**D**		**571**	**11.7**
Pipe, Conduit and Fittings	D		D		D	
Building Materials for All Structures	D		D		468	9.6
Siding, Siding Accessories & Structural Panels for Siding	--	--	--	--	D	
Flooring	--	--	--	--	D	
Insulation Material	D		--	--	431	8.9
All Other Building Materials for All Structures	D		D		D	
All Other Building and Construction	14	0.2	D		D	
ELECTRICAL/ELECTRONIC, TOTAL	**290**	**4.3**	**D**		**460**	**9.5**
Home and Industrial Appliances	119	1.8	D		D	
Communications Equipment	D		D		D	
Electric Equipment Combined with Electronic Components	28	0.4	D		D	
Storage Batteries	121	1.8	--	--	D	
Wire and Cable	D		--	--	D	
FURNITURE AND FURNISHINGS, TOTAL	**1,255**	**18.7**	**D**		**40**	**0.8**
Rigid Furniture	D		--	--	26	0.5
Flexible Furniture	D		D		--	--
Carpet and Carpet Components	816	12.1	--	--	--	--
Other Textiles and Furnishings	D		--		14	0.3
CONSUMER AND INSTITUTIONAL PRODUCTS, TOTAL	**966**	**14.5**	**D**		**1,668**	**34.3**
Disposable Food Serviceware (Includes Disposable Cups)	46	0.7	D		915	18.8
Health Care and Medical Products	442	6.6	D		115	2.4
Toys and Sporting Goods	54	0.8	D		135	2.8
Hobby and Graphic Arts Supplies	24	0.4	D		107	2.2
All Other Consumer and Institutional Products	400	6.0	D		396	8.1
INDUSTRIAL/MACHINERY, TOTAL	**D**		**D**		--	--
ADHESIVES/INKS/COATINGS, TOTAL	**D**		--	--	**D**	
Adhesives and Sealants	D		--	--	--	--
All Other Inks and Coatings	--	--	--	--	D	
ALL OTHER, TOTAL	**1,167**	**17.4**	**211**	**15.8**	**577**	**11.9**
EXPORTS, TOTAL	**1,245**	**18.5**	**199**	**14.9**	**113**	**2.3**
GRAND TOTAL	**6,720**	**100.0**	**1,335**	**100.0**	**4,860**	**100.0**

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Major Markets

1987 PLASTIC RESINS SALES & CAPTIVE USE

THERMOPLASTICS

MARKET	STYRENE LATEX & OSBP		NYLON		PVC	
	Quantity	Percent Of Total	Quantity	Percent Of Total	Quantity	Percent Of Total
TRANSPORTATION, TOTAL	**D**		**164**	**32.9**	**D**	
Motor Vehicles and Parts	D		156	31.3	D	
Ships, Boats and Recreational Vehicles	D		D		D	
All Other Transportation Equipment	D		D		D	
PACKAGING, TOTAL	**80**	**6.4**	**51**	**10.2**	**614**	**7.6**
Bottles, Jars, Vials	--	--	--	--	177	2.2
Food Containers (Excluding Disposable Cups)	D		D		D	
Flexible Packaging (Bags, Liners, Etc.)	--	--	D		212	2.6
Household and Institutional Refuse Bags & Film	--	--	D		D	
All Other Flexible Packaging	--	--	D		159	2.0
All Other Packaging	D		D		185	2.3
BUILDING AND CONSTRUCTION, TOTAL	**D**		**D**		**5,056**	**62.6**
Pipe, Conduit and Fittings	--	--	D		3,576	44.3
Building Materials for All Structures	D		D		1,185	14.6
Siding, Siding Accessories & Structural Panels for Siding	D		--	--	622	7.7
Flooring	D		--	--	330	4.1
Insulation Material	D		D		4	0.0
All Other Building Materials for All Structures	D		D		229	2.8
All Other Building and Construction	D		D		295	3.7
ELECTRICAL/ELECTRONIC, TOTAL	**D**		**94**	**18.8**	**524**	**6.5**
Home and Industrial Appliances	D		D		D	
Communications Equipment	--	--	D		D	
Electric Equipment Combined with Electronic Components	D		55	11.0	D	
Storage Batteries	--	--	D		D	
Wire and Cable	D		D		310	3.8
FURNITURE AND FURNISHINGS, TOTAL	**376**	**30.0**	**10**	**2.0**	**292**	**3.6**
Rigid Furniture	--	--	D		D	
Flexible Furniture	--	--	D		D	
Carpet and Carpet Components	350	27.9	D		D	
Other Textiles and Furnishings	26	2.1	D		207	2.6
CONSUMER AND INSTITUTIONAL PRODUCTS, TOTAL	**D**		**36**	**7.2**	**265**	**3.3**
Disposable Food Serviceware (Includes Disposable Cups)	D		D		D	
Health Care and Medical Products	D		D		73	0.9
Toys and Sporting Goods	D		D		D	
Hobby and Graphic Arts Supplies	--	--	D		7	0.1
All Other Consumer and Institutional Products	D		21	4.2	D	
INDUSTRIAL/MACHINERY, TOTAL	**D**		**32**	**6.4**	**D**	
ADHESIVES/INKS/COATINGS, TOTAL	**401**	**31.9**	**D**		110	**1.4**
Adhesives and Sealants	67	5.3	D		62	0.8
All Other Inks and Coatings	334	26.6	D		48	0.6
ALL OTHER, TOTAL	**D**		**45**	**9.0**	**620**	7.7
EXPORTS, TOTAL	**77**	**6.1**	**59**	**11.8**	**430**	**5.3**
GRAND TOTAL	**1,254**	**100.0**	**499**	**100.0**	**8,081**	**100.0**

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Major Markets

1987 PLASTIC RESINS SALES & CAPTIVE USE

THERMOPLASTICS

(Millions of Pounds, Dry Weight Basis)

MARKET	PVAC & OTHER VINYL		THERMOPLASTIC POLYESTER		ENGINEERING	
	Quantity	Percent Of Total	Quantity	Percent Of Total	Quantity	Percent Of Total
TRANSPORTATION, TOTAL	**D**		**D**		**D**	
Motor Vehicles and Parts	D		D		D	
Ships, Boats and Recreational Vehicles	D		D		D	
All Other Transportation Equipment	D		--	--	D	
PACKAGING, TOTAL	**D**		**985**	**69.8**	**18**	**1.9**
Bottles, Jars, Vials	--	--	879	62.3	D	
Food Containers (Excluding Disposable Cups)	--	--	D		D	
Flexible Packaging - (Bags, Liners, Etc.)	D		D		D	
Household and Institutional Refuse Bags & Film	D		D		--	--
All Other Flexible Packaging	D		D		D	
All Other Packaging	D		D		D	
BUILDING AND CONSTRUCTION, TOTAL	**19**	**2.1**	**D**		**82**	**8.6**
Pipe, Conduit and Fittings	--	--	D		D	
Building Materials for All Structures	D		--	--	D	
Siding, Siding Accessories & Structural Panels for Siding	--	--	--	--	--	--
Flooring	--	--	--	--	--	--
Insulation Material	--	--	--	--	--	--
All Other Building Materials for All Structures	D		--	--	2	0.2
All Other Building and Construction	D		D		D	
ELECTRICAL/ELECTRONIC, TOTAL	**D**		**D**		**D**	
Home and Industrial Appliances	D		D		D	
Communications Equipment	D		D		D	
Electric Equipment Combined with Electronic Components	D		D		89	9.3
Storage Batteries	--	--	--	--	D	
Wire and Cable	--	--	D		D	
FURNITURE AND FURNISHINGS, TOTAL	**48**	**5.3**	**D**		**D**	
Rigid Furniture	--	--	D		D	
Flexible Furniture	--	--	D		--	--
Carpet and Carpet Components	D		--	--	--	--
Other Textiles and Furnishings	D		D		D	
CONSUMER AND INSTITUTIONAL PRODUCTS, TOTAL	**D**		**D**		**63**	**6.6**
Disposable Food Serviceware (Includes Disposable Cups)	--	--	D		D	
Health Care and Medical Products	D		D		30	3.1
Toys and Sporting Goods	--	--	D		D	
Hobby and Graphic Arts Supplies	--	--	D		D	
All Other Consumer and Institutional Products	D		D		31	3.2
INDUSTRIAL/MACHINERY, TOTAL	**--**	**--**	**6**	**0.4**	**37**	**3.9**
ADHESIVES/INKS/COATINGS, TOTAL	**600**	**65.8**	**D**		**--**	**--**
Adhesives and Sealants	258	28.3	D		--	--
All Other Inks and Coatings	342	37.5	D		--	--
ALL OTHER, TOTAL	**D**		**57**	**4.0**	**106**	**11.1**
EXPORTS, TOTAL	**81**	**8.9**	**185**	**13.1**	**215**	**22.5**
GRAND TOTAL	**912**	**100.0**	**1,411**	**100.0**	**956**	**100.0**

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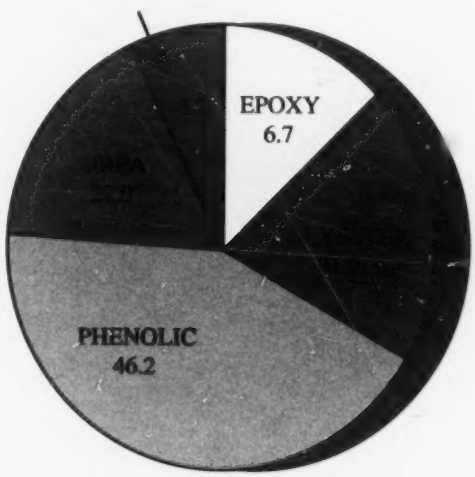
The Society of the Plastics Industry, Inc.

Thermoset Resins

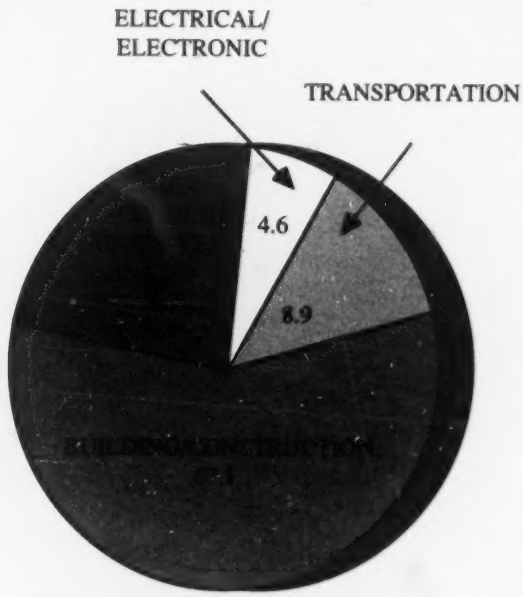
SUMMARY STATISTICS

Plastics which in their final state as finished articles are substantially infusible and insoluble. They are often liquids at some state of their manufacture or processing, which are cured by heat, catalysts or other chemical means. After being fully cured, thermosets cannot be resoftened by heat.

1987 PERCENT OF THERMOSET SALES & CAPTIVE USE



1987
PERCENT OF THERMOSET RESIN
SALES & CAPTIVE USE
BY MATERIAL



1987
PERCENT OF THERMOSET RESIN
SALES & CAPTIVE USE
BY MAJOR MARKET

NOTE: Includes data from reporting companies only. No estimates are included.

Source: SPI Major Market Report, SPI Comittee on Resin Statistics as compiled by Ernst & Whinney

EPOXY

MANUFACTURERS*

Ciba-Geigy Corp.
Dow Chemical U.S.A
Interez, Inc.
Reichhold Chemicals, Inc.
Shell Chemical Co.
Union Carbide Corp.

*Those manufacturers who participated in the SPI Monthly Statistical Report in 1987

PRODUCTION AND SALES & CAPTIVE USE

YEAR	PRODUCTION	SALES & CAPTIVE USE
1977	261	278
1978	299	316
1979	361	332
1980	315	319
1981	336	332
1982	286	301
1983	334	331
1984	406	379
1985	385	367
1986	398	376
1987	433	419
Average Annual Growth 1977-1987	5.2	4.2

DOMESTIC CONSUMPTION BY END-USE

(millions of pounds)

END-USE	1983	1984	1985	1986	1987
Bonding & adhesives	15	20	17	19	22
Flooring, paving and aggregates	19	18	17	19	21
Protective coatings	131	153	168	160	171
Fiber reinforced laminates & composites	74	87	69	69	72
Tooling, casting, and molding resins	28	31	23	23	24
All other cases	29	29	31	29	34
Total	**296**	**338**	**325**	**319**	**344**

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

EPOXY

DISTRIBUTION BY MAJOR MARKET

(in millions of pounds)

MAJOR MARKET	1983	1984	1985	1986	1987
Transportation	*	*	*	*	*
Packaging	*	*	*	*	*
Building and Construction	36	36	39	38	47
Electrical/Electronic	73	82	72	80	74
Furniture and Furnishings	*	*	*	*	*
Consumer and Institutional	--	*	*	*	*
Industrial/Machinery	*	*	*	*	*
Adhesives/Inks/Coatings	118	122	140	140	148
All Other	69	98	74	61	69
Exports	35	41	42	57	75
Total	**331**	**379**	**367**	**376**	**419**

*Included in All Other

Source: SPI Committee on Resin Statistics Annual Major Markets Survey

TYPICAL APPLICATIONS

Coatings
Electrical laminates
Floor/paving aggregates
Reinforced composites
Electrical/Electronic casting
Adhesives and molding

PHENOLIC

MANUFACTURERS*

Allied Bendix
Ametek, Haveg Div.
Ashland Chemical Co.
Borden Chemical Co., Inc.
Chembond Corp.
Formica Corp.
Georgia-Pacific Corp.
Hoechst Celanese
Inmont Corp.
Ironsides Resins, Inc.
Koppers Co.
Occidental Chemical Corp.
Owens-Corning Fiberglas Corp.
Perkins Industries, Inc.
Plaslok Corp.
Plastics Engineering Co.
Polyrez Co., Inc.
Raymark Industries, Inc.
Reichhold Chemicals, Inc.
Rogers Corp.
Sterling Engineered Products
Union Carbide Corp.
Valite Div., Valentine Sugars, Inc.

*Those manufacturers who participated in the SPI Monthly Statistical Report in 1987

PRODUCTION AND SALES & CAPTIVE USE*

YEAR	PRODUCTION	SALES & CAPTIVE USE
1977	1,458	1,400
1978	1,827	1,788
1979	1,781	1,732
1980	1,499	1,517
1981	2,333	2,375
1982	2,006	2,060
1983	2,484	2,529
1984	2,502	2,510
1985	2,621	2,640
1986	2,735	2,771
1987	2,869	2,871

*Gross weight basis of reporting begun in 1981 so data are not comparable before then.

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

PHENOLIC

DOMESTIC CONSUMPTION BY END-USE

(in millions of pounds)

END-USE	1983	1984	1985	1986	1987
Molding compounds	232	238	209	206	195
Bonding & adhesive resins for:					
Laminating	166	149	142	200	191
Coated & bonded abrasives	28	23	16	19	20
Friction materials	32	35	26	29	32
Insulation materials	355	307	419	425	435
Foundry & shell molding	70	81	77	42	44
Plywood	1,309	1,319	1,255	1,450	1,558
Fibrous & granulated wood	179	184	217	244	247
Resins sold to Rubber Industry	27	30	28	31	18
All other	59	62	159	66	35
Protective coatings	19	22	23	24	24
All other uses	30	38	48	20	54
Total	**2,506**	**2,488**	**2,619**	**2,756**	**2,853**

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

DISTRIBUTION BY MAJOR MARKET

(in millions of pounds)

MAJOR MARKET	1983	1984	1985	1986	1987
Transportation	156	150	124	85	63
Packaging	*	*	*	*	*
Building and Construction	1,936	1,921	1,950	2,278	2,394
Electrical/Electronic	176	162	128	130	122
Furniture and Furnishings	*	*	*	*	*
Consumer and Institutional	44	*	*	*	*
Industrial/Machinery	11	9	7	*	*
Adhesives/Inks/Coatings	70	80	82	68	67
All Other	113	166	328	194	207
Exports	23	22	21	16	18
Total	**2,529**	**2,510**	**2,640**	**2,771**	**2,871**

*Included in All Other

Source: SPI Committee on Resin Statistics Annual Major Markets Survey

TYPICAL APPLICATIONS

Wiring devices	Electrical switch gear	Rubber tackifiers
Connectors	Closures	Laminating plywood
Transmission parts	Handles	Knobs
Pulleys	Telephone relay systems	Power brake components

UNSATURATED POLYESTER

MANUFACTURERS*

Advance Coatings Corp.
Alpha Chemical Corp.
Aristech Chemical Co.
Ashland Chemical Co.
AZS Corp.
Cook Paint & Varnish Co.
Dow Chemical U.S.A.
Freeman Chemical Corp.
Glidden Coatings & Resin Div. SCM Corp.
ICI Americas, Inc.
Inmont Corp.
Interplastics Corp.
Koppers Co.
Owens-Corning Fiberglas Corp.
Reichhold Chemicals, Inc.
SILMAR Div. of SOHIO Chem. Co.
Sterling Engineered Products

*Those manufacturers who participated in the SPI Monthly Statistical Report in 1987

PRODUCTION AND SALES & CAPTIVE USE

(millions of pounds)

YEAR	PRODUCTION	SALES & CAPTIVE USE
1977	1,061	1,045
1978	1,209	1,199
1979	1,147	1,152
1980	947	949
1981	997	977
1982	865	851
1983	1,084	1,072
1984	1,232	1,231
1985	1,223	1,233
1986	1,271	1,265
1987	1,367	1,362
Average Annual Growth		
1977-1987	2.6%	2.7%

TYPICAL APPLICATIONS

Panels
Tanks
Auto components
Sanitary fixtures
Synthetic marble
Recreational vehicles
Pleasure boats
Bowling balls
Showerstalls

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

UNSATURATED POLYESTER

MAJOR DOMESTIC MARKETS

(in millions of pounds)

	1983	1984	1985	1986	1987
DOMESTIC REINFORCED PLASTICS, TOTAL	**818**	**939**	**949**	**947**	**1,030**
Marine and marine accessories	215	249	246	265	302
Transportation	88	99	120	107	106
Auto, trucks, buses, etc.	75	83	100	88	89
Other transportation	13	16	20	19	17
Construction	340	389	382	382	445
General construction	135	172	158	145	151
Bathroom components & fixtures, general purpose tanks & pipes	93	100	112	124	160
Corrosion resistant tanks, pipes, etc.	112	117	112	113	134
Electrical generation, transmission and distribution	26	37	27	27	26
Consumer goods	81	85	96	84	66
Major appliances and parts	21	19	21	21	20
Recreational goods, toys, etc.	40	39	42	32	23
Other consumer goods	20	27	33	31	23
Gel coats	36	43	38	42	45
Other reinforced	32	37	40	40	40
DOMESTIC NON-REINFORCED PLASTICS, TOTAL	**244**	**283**	**276**	**309**	**322**
Castings	118	161	160	173	184
Furniture	4	5	7	5	5
Cultured marble & onyx	81	107	107	121	131
Other	33	49	46	47	48
Autobody putty	61	56	61	69	72
Surface and protective coatings	5	5	6	8	8
Bonding and adhesives	2	3	2	4	2
Minebolt anchor resins	NA	21	20	NA	26
Other non-reinforced	58	37	27	55	30

DISTRIBUTION BY MAJOR MARKET

(in millions of pounds)

MAJOR MARKET	1983	1984	1985	1986	1987
Transportation	316	388	411	428	472
Packaging	--	--	--	--	*
Building and Construction	496	502	487	505	541
Electrical/Electronic	52	66	61	59	48
Furniture and Furnishings	2	11	11	11	22
Consumer and Instititutional	81	72	60	70	98
Industrial/Machinery	*	*	*	24	*
Adhesives/Inks/Coatings	*	*	*	*	*
All Other	115	184	194	159	171
Exports	10	8	9	9	10
Total	**1,072**	**1,231**	**1,233**	**1,265**	**1,362**

NA = Not Available *Included in all other

Sources: Quarterly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney
SPI Committee on Resin Statistics Annual Major Markets Survey

UREA

MANUFACTURERS*

American Cyanamid Co.
Borden Chemical Co., The
Chembond Corp.
Dan River, Inc.
Georgia-Pacific Corp.
Grifftex Chemicals, Inc.
Harborchem, Inc.
Interez, Inc.
Monsanto Co.
Perkins Industries
Perstorp Compounds, Inc.
Reichhold Chemicals, Inc.
Sterling Engineered Products
Valchem Div. United Merchants, Inc.

*Those manufacturers who participated in the SPI Monthly Statistical Report in 1987

PRODUCTION AND SALES & CAPTIVE USE

(millions of pounds)

YEAR	PRODUCTION	SALES & CAPTIVE USE
1977	963	951
1978	1,122	1,103
1979	1,367	1,355
1980	1,165	1,147
1981	1,165	1,139
1982	998	976
1983	1,172	1,167
1984	1,199	1,189
1985	1,210	1,203
1986	1,271	1,266
1987	1,382	1,368
Average Annual Growth		
1977-1987	3.7%	3.7%

Sources: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

MELAMINE

MANUFACTURERS*

American Cyanamid Co.
Borden Chemical Co., The
Chembond Corp.
Formica Corp.
Grifftex Chemicals, Inc.
Harborchem, Inc.
Hoechst Celanese
Interez, Inc.
Monsanto Co.
Perstorp Compounds, Inc.
Reichhold Chemicals, Inc.
Sterling Engineered Products

*Those manufacturers who participated in the SPI Monthly Statistical Report in 1987

PRODUCTION AND SALES & CAPTIVE USE

(millions of pounds)

YEAR	PRODUCTION	SALES & CAPTIVE USE
1977	200	203
1978	202	196
1979	200	192
1980	167	166
1981	179	175
1982	158	155
1983	180	181
1984	210	197
1985	192	194
1986	173	191
1987	212	198
Average Annual Growth		
1977-1987	0.6%	-0.3%

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

UREA AND MELAMINE

DOMESTIC CONSUMPTION BY END USE

(in millions of pounds)

END-USE	1983	1984	1985	1986	1987
Textile treating & coating resins	NA	23	17	21	24
Paper treating & coating resins	74	988	100	97	80
Bonding & adhesive resins for:					
Laminating	40	44	45	45	51
Plywood	63	59	57	60	58
Fibrous & granulated wood	918	944	955	1,029	1,128
Protective coatings	76	84	89	102	110
All other uses	155	134	134	102	115
Total	**1,326**	**1,386**	**1,397**	**1,456**	**1,566**

NA = Not Available
Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

DISTRIBUTION BY MAJOR MARKET

(in millions of pounds)

MAJOR MARKET	1983	1984	1985	1986	1987
Transportation	*	*	*	*	*
Packaging	45	32	30	33	31
Building and Construction	844	896	1,009	1,093	1,193
Electrical/Electronic	*	*	*	*	*
Furniture and Furnishings	*	*	43	37	38
Consumer and Institutional	*	*	116	*	*
Industrial/Machinery	--	--	--	--	--
Adhesives/Inks/Coatings	*	*	*	*	*
All Other	438	458	199	294	304
Exports	21	*	*	*	*
Total	**1,348**	**1,386**	**1,397**	**1,457**	**1,566**

*Included in All Other
Source: SPI Committee on Resin Statistics Annual Major Markets Survey

TYPICAL APPLICATIONS

UREA		MELAMINE	
Wiring devices	Buttons	Adhesives and bonding	Dinnerware
Toilet seats	Knobs	Buttons	Knobs
Handles	Adhesives and bonding	Handles	Ashtrays

POLYURETHANE FOAM

DOMESTIC SALES & CAPTIVE USE

(in millions of pounds)

	1981	1982	1983	1984	1985	Compound Growth Rate 1980-1985
Flexible and Semi-Flexible Foam						
Bedding (excluding sofa beds)	143	125	149	165	150	1.5%
Furniture	437	431	503	500	500	3.0
Packaging	35	34	38	40	35	8.8
Rug and Underlay	165	141	165	170	125	- 4.9
Textile Laminates	36	34	39	40	35	- 1.6
Transportation	227	216	269	300	350	7.6
Miscellaneous	40	43	35	45	60	0.7
Scrap	101	103	113	140	125	9.4
Total Flexible and Semi-Flexible Foam	**1,184**	**1,127**	**1,311**	**1,400**	**1,380**	**3.3%**
Rigid Foam						
Appliances	76	80	87	100	125	12.6%
Building Construction	328	328	379	400	430	6.4
Furniture	16	21	16	20	15	- 7.4
Marine Flotation	15	12	10	10	10	- 7.8
Packaging	42	43	47	50	45	5.8
Transportation	41	32	32	30	50	1.7
Miscellaneous	42	31	27	40	75	14.6
Total Rigid Foam	**560**	**547**	**598**	**650**	**750**	**6.8%**
Grand Total Foam	**1,744**	**1,674**	**1,909**	**2,050**	**2,130**	**4.5%**

Source: SPI Committee on Resin Statistics, as compiled by Ernst & Whinney
Note: Base Survey not available in 1986 or 1987

DISTRIBUTION OF POLYURETHANE FOAM

SALES AND USE BY MAJOR MARKET

(in millions of pounds)

	Quantity					% of Total				
	1981	1982	1983	1984	1985	1981	1982	1983	1984	1985
Transportation	**268**	**248**	**301**	**330**	**400**	**15.4%**	**14.8%**	**15.8%**	**16.1%**	**18.8%**
Flexible	227	216	269	300	350	13.0	12.9	14.1	14.6	16.4
Rigid	41	32	32	30	50	2.4	1.9	1.7	1.5	2.4
Packaging	**77**	**77**	**85**	**90**	**80**	**4.4**	**4.6**	**4.3**	**4.4**	**3.8**
Flexible	35	34	38	40	35	2.0	2.0	2.0	2.0	1.7
Rigid	42	43	47	50	45	2.4	2.6	2.3	2.4	2.1
Furniture/ Furnishings	**898**	**859**	**872**	**895**	**790**	**51.5**	**51.3**	**45.7**	**43.7**	**37.1**
Flexible	882	838	856	875	775	50.6	49.8	44.8	42.7	36.4
Rigid	16	21	16	20	15	0.9	1.5	0.9	1.0	0.7
Building/ Contruction	**328**	**328**	**379**	**400**	**430**	**18.8**	**19.6**	**19.9**	**19.5**	**20.2**
Electrical/ Electronic	**76**	**80**	**87**	**100**	**125**	**4.4**	**4.8**	**4.6**	**4.8**	**5.8**
All Other	**97**	**82**	**185**	**235**	**305**	**5.5**	**4.9**	**9.7**	**11.5**	**14.3**
Total	**1,744**	**1,674**	**1,909**	**2,050**	**2,130**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

ISOCYANATES

PRODUCTION				SALES & CAPTIVE USE
Year	Total	TDI*	Other Isocyanates	Total
1983	1,156	624	532	1,135
1984	1,331	680	651	1,312
1985	1,312	629	683	1,294
1986	1,346	654	692	1,349
1987	1,534	705	829	1,516

*Toluene Diisocyanate (80/20 mixture)

POLYETHER POLYOLS

(in millions of pounds)

Year	Production	Sales & Captive Use
1983	1,296	1,286
1984	1,347	1,305
1985	1,391	1,407
1986	1,452	1,453
1987	1,626	1,653

POLYESTER POLYOLS

(in millions of pounds)

Year	Production	Sales & Captive Use
1983	29	26
1984	26	26
1985	41	40
1986	47	46
1987	56	55

PARTICIPATING COMPANIES--1987	Isocyanates	Polyether Polyols	Polyester Polyols
ARCO Chemical Co.		X	
BASF Corp.	X	X	
Brinmont Chemicals, Inc.			X
Chemical Exchange Industries			X
Chemetic Systems		X	
Choate Chemical		X	
Dow Chemical U.S.A.	X	X	
E.I. duPont de Nemours & Co.		X	
Freeman Chemical - Chardenol Division			X
Hercules, Inc.		X	X
ICI Americas, Inc.	X	X	
Inolex Chemical Co.			X
Mobay Chemical Corp.	X	X	
Olin Corp.	X	X	
Owens-Corning Fiberglas Corp.		X	
Q.O. Chemical		X	
Ruco Div. Occidental Chemicals Corp.			X
Stepan Chemical Co.		X	X
Sterling Engineered Products			X
Texaco, Inc.		X	
Union Carbide Corp.		X	X
Uniroyal Chemical Co.			X
Witco Chemical Corp.		X	X

Source: Isocyanates and Polyols Reports, SPI Committee on Resin Statistics as compiled by Ernst & Whinney

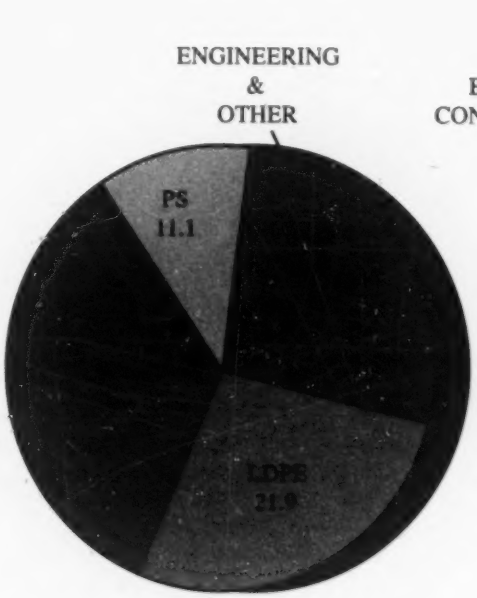
The Society of the Plastics Industry, Inc.

Thermoplastic Resins

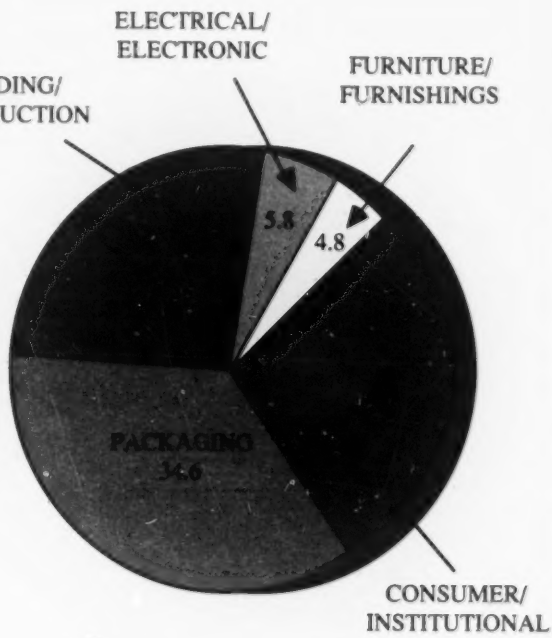
SUMMARY STATISTICS

Plastics which are capable of being repeatedly softened by increase of temperature and hardened by decrease of temperature in their final state as finished articles.

1987 PERCENT OF THERMOPLASTIC SALES & CAPTIVE USE



1987 PERCENT OF THERMOPLASTIC SALES & CAPTIVE USE BY MATERIAL



1987 PERCENT OF THERMOPLASTIC SALES & CAPTIVE USE BY MAJOR MARKET

NOTE: Includes data from reporting companies only. No estimates are included.

Source: SPI Major Market Report, SPI Committee on Resin Statistics as compiled by Ernst & Whinney

ABS AND SAN

MANUFACTURERS*

Borg Warner Chemicals
Dow Chemical U.S.A.
B.F. Goodrich Chemical Co.
W.R. Grace & Co.
Monsanto Company

*Those companies who participated in the SPI Monthly Statistical Report in 1987

PRODUCTION AND SALES & CAPTIVE USE

(millions of pounds)

YEAR	PRODUCTION		SALES & CAPTIVE USE	
	ABS	SAN	ABS	SAN
1977	1,069	115	1,057	113
1978	1,134	120	1,118	121
1979	1,191	124	1,183	126
1980	920	111	916	103
1981	916	107	900	105
1982	740	91	737	85
1983	NA	93	NA	91
1984	1,128	99	1,098	88
1985	1,028	87	1,016	84
1986	1,092	92	1,080	87
1987	1,175	126	1,208	127
Average Annual Growth 1977-1987	1.0%	1.0%	1.3%	1.2%

NA = Not Available

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

ABS AND SAN

DISTRIBUTION OF ABS AND SAN BY MAJOR MARKET

(in millions of pounds)

MAJOR MARKET	1983[a]	1984	1985	1986	1987
Transportation	267	267	269	285	*
Packaging	51	13	*	5	*
Building and Construction	197	*	134	133	*
Electrical/Electronic	246	269	241	261	*
Furniture and Furnishings	7	*	*	*	*
Consumer and Institutional	168	*	*	*	*
Industrial/Machinery	47	*	*	*	*
Adhesives/Inks/Coatings	27	*	*	*	*
All Other	175	638	456	484	1,136
Exports	144	*	*	*	199
Total	**1,329**	**1,187**	**1,100**	**1,168**	**1,335**

*Included in All Other

[a]Includes Other Styrene Based Polymers

TYPICAL APPLICATIONS

ABS

Household appliances
Telephones
Bath tubs
Business machines
Refrigerator liners
Sporting goods

SAN

Automotive trim
Marine instruments
Tractor components
Boat hulls
Solar collectors
Swimming pool components

Source: SPI Committee on Resin Statistics Annual Major Markets Survey

ENGINEERING THERMOPLASTIC RESINS

The following resins are generally considered to be included in the category of engineering resins: fluoropolymers; polyimides and polyamide-imides; modified polyphenylene oxide; polyphenylene sulfide; thermoplastic polyester resin; polycarbonate; polysulfone; and acetal. Other materials which may be used in similiar applications such as ABS, SAN, and nylon are mentioned elsewhere in Facts & Figures. Fluoropolymers, likewise, are mentioned elsewhere.

Engineering resins are characterized by a combination of high ratings for mechanical, thermal, electrical, and chemical properties. Fillers such as glass, carbon, metallic oxides, metallic powders, calcium carbonate, and silica products, and reinforcements such as fibrous glass, carbon, and other inorganic and organic fibers are added to improve these properties.

TYPICAL APPLICATIONS

Acetal (AC)	Fasteners, knobs, bushings, bearings, faucets, valves, seat belt components, conveyor belts, zippers, disposable lighter bodies.
Fluoropolymers	Wire & cable jacketing, nonstick coatings, bearing pads, laminates.
Polycarbonate (PCO)	Microwave cookware, filter housings, bottles, lamp housings, drapery fixtures, safety glazing, nameplates, food processor bowls.
Polyphenylene Sulfide (PPS)	Pumps, hair dryers, small cooking appliances, automotive components.
Thermoplastic Polyester (TP)	Lighting, microwave cookware, bearings, beverage bottles, food containers, auto grilles, switches.
Polysulfone (PSO)	Food processing equipment, circuit boards, camera and watch cases, purification devices, connectors.
Modified Polyphenylene Oxide(PPO)	Personal computers, auto instrument panels, wheel covers, pump housings, radomes, fuse boxes, TV cabinetry.
Polyimide (PI)	Printed wiring boards, gears, electric motors, radomes, bearings.
Polyamide-imide (PAI)	Seals, valve train components, jet engine components, transmissions.

ENGINEERING THERMOPLASTIC RESINS

MANUFACTURING

KNOWN MANUFACTURERS	AC	PCO	PPS	TP	PSO	PPO	PI	PAI	FLUORO-POLYMERS
Allied				X					
Amoco Chemical					X		X	X	
Ausimont									X
Borg Warner Chemicals						X			
Dow Chemical		X							
DuPont	X			X			X		X
Eastman Chemical				X					
General Electric		X		X		X	X		
Goodyear				X					
Hoechst Celanese	X			X					
ICI Americas				X					X
Mobay Chemical		X							
Pennwalt Corp.									X
Phillips Petroleum			X						

PRODUCTION AND SALES & CAPTIVE USE[1]

(in millions of pounds and dollars)

YEAR	PRODUCTION	SALES & CAPTIVE USE
1977	605	576
1978	648	639
1979	729	709
1980	673	645
1981	676	633
1982	569	596
1983	731	781
1984	878	892
1985	834	839
1986	877	840
1987	1,036	957

COMPOUND GROWTH RATE OF SALES & CAPTIVE USE	
1977-1987	5.1%
1982-1987	10.0%
1984-1985	- 6.0%
1985-1986	0.1%
1986-1987	13.9%

DISTRIBUTION BY MAJOR MARKET[1]

(in millions of pounds)

MAJOR MARKET	1982	1983	1984	1985	1986	1987
Transportation	80	123	136	140	*	*
Packaging	1	2	2	14	15	18
Building & Construction	82	76	101	79	84	82
Electrical/Electronic	192	275	305	250	236	*
Consumer/Institutional	45	82	90	28	31	63
Industrial/Machinery	52	75	88	37	43	37
Other	18	26	70	88	244	541
Exports	126	122	100	203	187	215
Total	**596**	**781**	**892**	**839**	**840**	**956**

Source: SPI Committee on Resin Statistics as compiled by Ernst & Whinney

[1] Excludes Thermoplastic Polyester resins

* Included in other

FLUOROPOLYMER RESINS

U.S. SALES (GRANULAR TYPE ONLY)

(in millions of pounds)

	1981	1982	1983	1984	1985
Virgin, First Quality	7,699	5,651	6,898	7,969	7,406
Filled Resin, including colors	3,265	2,283	3,131	4,061	4,006
Miscellaneous lubricants, release compounds, etc.[1]	3,503	2,493	2,524	3,034	3,549
Total	**14,467**	**10,427**	**12,553**	**15,064**	**14,961**

[1] Includes broad specification second quality.
Source: SPI's Fluoropolymers Division

COMPOUND GROWTH RATE

1980-1985

Virgin, First Quality	0.2%
Filled Resin, including colors	7.1%
Miscellaneous lubricants, release compounds, etc.	1.2%
Total	2.1%

SUPPLIERS OF GRANULAR PTFE RESINS

Ausimont, Inc.
Custom Compounding
E.I. duPont de Nemours & Co.
Hoechst Celanese
ICI Americas
LNP Corporation

TYPICAL APPLICATIONS

Plenum cable
Non-stick coatings
Wire ties
Chemical processing equipment
Filter housings
Valves
Electrical components
Tower packings
Heat-shrinkable tubing

NOTE: SPI report not done in 1986 or 1987.

HIGH DENSITY POLYETHYLENE

MANUFACTURERS*

Allied Chemical Co.	Exxon Chemical Co.	Mobil Chemical Co.
Cain Chemical Co.	Himont U.S.A.	Phillips Chemical Co.
Chevron Chemical Olefins	Hoechst Celanese	Soltex Polymers
Dow Chemical U.S.A.	Quantum Chemical Corp.	Union Carbide Corp.

*Those manufacturers who participated in the SPI Monthly Statistcal Report in 1987

	CAPACITY	UTILIZATION RATE (%)
1977	4,306	84.8
1978	4,895	85.8
1979	5,323	94.1
1980	5,921	74.4
1981	5,995	78.3
1982	6,439	76.5
1983	6,888	82.6
1984	7,341	82.9
1985	7,408	90.1
1986	7,301	98.4
1987	7,997	99.9

PRODUCTION AND SALES & CAPTIVE USE

(millions of pounds)

YEAR	PRODUCTION	SALES & CAPTIVE USE
1977	3,652	3,557
1978	4,201	4,165
1979	5,010	4,893
1980	4,405	4,394
1981	4,695	4,683
1982	4,928	5,024
1983	5,691	5,707
1984	6,085	5,949
1985	6,671	6,651
1986	7,182	7,028
1987	7,995	8,155
Compound Growth Rate		
1977-1987	8.1%	8.6%

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

HIGH DENSITY POLYETHYLENE

DOMESTIC CONSUMPTION BY END-USE

(in millions of pounds)

END-USE	1983	1984	1985	1986	1987
Film (12 mils & below)	375	371	437	497	650
Sheet (over 12 mils)	76	121	140	177	231
Injection molding	1,188	1,191	1,538	1,550	1,780
Wire & cable	112	123	113	119	106
Extrusion coating	NA	NA	NA	NA	NA
Blow molding	1,808	2,079	2,245	2,400	2,884
Pipe & conduit	471	473	478	444	593
Other extruded products	42	45	36	50	61
All other uses	634	850	787	866	967
Total	**4,706**	**5,253**	**5,774**	**6,103**	**7,272**

NA = Not Available

Source: Monthly Statistical Report, SPI Committee on Resin Statistics as complied by Ernst & Whinney.

DISTRIBUTION BY MAJOR MARKET

MAJOR MARKET	1983	1984	1985	1986	1987
Transportation	121	*	183	232	213
Packaging	2,591	2,954	3,355	3,560	4,325
Building andConstruction	518	513	546	522	775
Electrical/Electronic	123	149	153	147	138
Furniture andFurnishings	*	*	46	*	*
Consumer and Institutional	526	488	507	783	896
Industrial/Machinery	109	161	141	132	159
Adhesives/Inks/Coatings	*	*	--	*	*
All Other	718	988	843	728	766
Exports	1,001	696	877	924	883
Total	**5,707**	**5,949**	**6,651**	**7,028**	**8,155**

*Included in All Other

TYPICAL APPLICATIONS

Grocery bags	Florist tissue	55-gal. drums
Bottles	Cables	Shipping containers
Agricultural tanks	Gasoline tanks	Seating

Source: SPI Committee on Resin Statistics Annual Major Markets Survey

HIGH DENSITY POLYETHYLENE

SELECTED END-USES

(in millions of pounds)

	1983	1984	1985	1986	1987
FILM	**370**	**361**	NA	**491**	**648**
Milinary/MerchandisingBags	165	168	NA	173	224
Food Packaging	101	76	NA	NA	137
All Other	104	117	NA	318	287
INJECTION MOLDING	**1,175**	**1,129**	NA	**1,562**	**1,771**
Industrial and Shipping Pails[1]	232	324	NA	433	483
Housewares[2]	175	105	NA	166	188
Crates and Totes[3]	146	112	NA	156	192
Toys	111	63	NA	66	52
Aerosol Overcaps, caps, closures	70	91	NA	70	90
Food Tubs or Containers	174	238	NA	176	271
All Other	267	196	NA	495	495
BLOW MOLDING	**1,733**	**2,027**	NA	**2,406**	**2,878**
Liquid Food Bottles	698	687	NA	802	886
Household Chemicals	600	657	NA	813	1,033
Industrial Drums	90	163	NA	171	219
Pharmaceuticals, Cosmetics & Toiletries	127	113	NA	174	235
All Other	218	407	NA	446	507
ROTOMOLDING	**64**	NA	NA	NA	NA
PIPE AND CONDUIT	**465**	**469**	NA	**453**	**592**
Corrugated	195	138	NA	143	162
Gas Distribution	74	126	NA	120	171
All Other	196	205	NA	190	259

NA = Not Available
[1] 5 gallons or less
[2] Includes household pails
[3] Includes beverage cases

Source: SPI Committee on Resin Statistics as compiled by Ernst & Whinney

Thermoplastic Resins

LATEX MATERIAL

Latex materials (sometimes referred to as emulsion polymers) are dispersions of the plastic polymer particles in water. Developed in the laboratory in the early 1930's, the first successful product was a synthetic rubber latex, commercialized during World War II to supplement the short supply of natural rubber latex.

A great variety and profusion of emulsions are now in commercial production. The most important of the plastic latexes are copolymers of styrene and butadiene, homopolymers and copolymers of vinyl acetate, acrylates, and vinyl chloride, as well as emulsions of polyvinyl chloride, and other specialties. Other co-monomers used include fumarate, maleate, and ethylene.

The non-plastic synthetic rubber latices, excluded from SPI statistics, are elastomers categorized as Styrene/Butadiene (high butadiene), Polybutadiene, Acrylonitrile/Butadiene, Chloroprene, and Butyl. There is a significant amount of inter-product competition, particularly among the plastic types, and further there is competition with the synthetic and natural rubber latices which historically have been used.

The major end-uses for these plastic latex materials lie in four areas: (1) Adhesives - primarily in the packaging, construction, and wood products areas; (2) Coatings - primarily as a vehicle in waterbased paints; (3) Paper - primarily as a clay coatings binder, but also used for saturating; and (4) Textiles - primarily as fabric finishes, sizes, back coats, and in fabric lamination and non-woven fiber bonding.

The emulsions and compounds are generally sold or used in relatively small batches (drums, tank trucks, and tank cars), and in many applications the emulsions are tailor-made to the end-use. There are thousands of end-users, some of whom polymerize for themselves, some of whom buy compounded material.

Each product sold has some unique characteristic desired in the end-use. For example, some adhesive resins should impart water resistance, fabric resins should be hard or soft depending on the type desired, and coatings resins should have good tint retention properties.

As a class these plastic emulsions have gained wide acceptance in the above mentioned end-uses for one or more of the following reasons:

- Water base (will meet the requirements of air pollution controls and regulations)
- Ease of clean-up
- Good adhesion to various substrates
- High pigment binding capacity
- Abrasion resistance and flexibility
- Uniform quality as compared with natural binders
- Good supply picture as compared with many of the natural binders
- Relative low cost versus binding efficiency
- Compatibility with existing technology and processes

STYRENE BUTADIENE & OTHER STYRENE BASED LATEXES

Significant producers are: Dow, General Tire & Rubber, Goodyear, W.R. Grace, Morton Industries, Polysar, Reichhold Chemicals and Union Chemical.

PRODUCTION AND SALES & CAPTIVE USE
(thousands of pounds)

		SALES & CAPTIVE USE*				
Year	Production	Paper Treating	Textile Treating	Carpet Backing	All Other	Total
1983	701,673	26,884	19,438	298,649	353,773	698,744
1984	745,109	24,400	15,483	315,811	393,302	748,996
1985	736,163	39,064	17,026	304,370	429,609	790,069
1986	823,305	55,722	20,438	315,581	475,572	867,313
1987	929,364	46,256	16,480	364,371	543,200	970,307

* Data may not be comparable due to variations in participation
Source: Monthly Statistical Report, SPI Committee on Resin Statistics as compiled by Ernst & Whinney

LOW DENSITY POLYETHYLENE [1]

MANUFACTURERS*

Chevron Chemical Olefins	Exxon Chemical Co.
Dow Chemical U.S.A.	Mobil Chemical Co.
DuPont	Quantum Chemical Corp.
Eastman Chemical Co.	Soltex
El Paso Products Co.	Union Carbide Corp.
	Westlake Polymers

*Those manufacturers who participated in the SPI monthly report in 1987

	CAPACITY	UTILIZATION RATE (%)
1977	7,908	81.8
1978	8,003	88.9
1979	7,977	97.7
1980	8,471	86.1
1981	9,761	78.8
1982	9,361	80.2
1983	8,655	93.0
1984	9,491	88.6
1985	9,973	89.2
1986	10,086	88.3
1987	10,491	91.5

PRODUCTION AND SALES & CAPTIVE USE

(millions of pounds)

YEAR	PRODUCTION	SALES & CAPTIVE USE
1977	6,471	6,488
1978	7,111	7,147
1979	7,793	7,815
1980	7,291	7,467
1981	7,693	7,516
1982	7,503	7,687
1983	8,041	8,045
1984	8,413	8,416
1985	8,899	8,790
1986	8,903	8,799
1987	9,599	9,611
Compound Growth Rate		
1977-1987	4.0%	4.0%

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

[1] Includes data for Linear Low Density Polyethylene

LOW DENSITY POLYETHYLENE

DOMESTIC CONSUMPTION BY END-USE

(in millions of pounds)

END-USE	1983	1984	1985	1986	1987
Film (12 mils & below)	4,628	4,689	4,777	4,787	5,234
Sheet (over 12 mils)	NA	NA	NA	NA	NA
Injection molding	657	612	583	574	697
Wire & cable	310	368	337	336	337
Extrusion coating	573	640	649	678	768
Blow molding	42	43	47	39	54
Pipe & conduit	25	27	28	32	48
Other extruded products	92	95	103	112	133
All other uses	800	968	1,136	1,301*	1,337*
Total	**7,127**	**7,442**	**7,660**	**7,859**	**8,609**

*Includes resellers and compounders

NA = Not Available

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

DISTRIBUTION BY MAJOR MARKET

(in millions of pounds)

MAJOR MARKET	1983	1984	1985	1986	1987
Transportation	*	*	*	*	*
Packaging	5,377	5,393	5,469	5,605	6,161
Building and Construction	226	313	327	213	377
Electrical/Electronic	374	430	403	421	420
Furniture and Furnishings	*	4	37	71	41
Consumer and Institutional	560	666	468	507	610
Industrial/Machinery	*	*	*	*	*
Adhesives/Inks/Coatings	*	67	111	231	337
All Other	589	569	844	812	662
Exports	919	974	1,131	939	1,003
Total	**8,045**	**8,416**	**8,790**	**8,799**	**9,611**

*Included in All Other

Source: SPI Committee on Resin Statistics Annual Major Markets Survey

TYPICAL APPLICATIONS

Stretch wrap
Diaper liners
Household cling wrap
Squeeze bottles
Housewares
Lids
Closures
Pipe
Toys

LOW DENSITY POLYETHYLENE

SELECTED END-USES

(in millions of pounds)

	1983	1984	1985	1986	1987
PACKAGING FILM	3,155	2,955	NA	3,027	3,390
Food Packaging	1,092	874	NA	980	945
Produce	146	74	NA	165	278
Bakery	256	243	NA	356	370
All Other	690	557	NA	459	297
Non-Food Packaging	1,692	1,705	NA	1,674	1,929
Industrial Liners	966	949	NA	696	712
Shipping Sacks	141	219	NA	262	351
All Other	585	537	NA	716	866
Pallet Shrink Film	107	72	NA	98	NA
All Other Shrink Film	81	69	NA	33	215
Stretch Film	183	235	NA	243	300
Non-Packaging Film	1,455	1,640	NA	1,724	1,801
Trash Bags	881	902	NA	976	994
Construction and Agriculture	164	194	NA	119	230
Disposable Diapers	NA	NA	NA	34	201
All Other	410	544	NA	495	376
INJECTION MOLDING	578	555	NA	581	694
Lids	160	140	NA	148	194
Toys and Novelties	31	23	NA	31	28
Housewares	221	223	NA	221	271
All Other	166	169	NA	181	201
EXTRUSION COATING	559	637	NA	708	768
Paperboard	338	384	NA	367	443
All Other	221	253	NA	341	325
Wire & Cable	NA	NA	NA	338	337
ROTOMOLDING RESINS	23	56	NA	89	157

NA = Not Available

Source: SPI, Committee on Resin Statistics as compiled by Ernst & Whinney

Thermoplastic Resins

NYLON

MANUFACTURERS*

Allied Chemical Co.	Custom Resins, div. Bemis Co.	Monsanto Company
ATOCHEM Inc.	DuPont	Nylon Corp. of America
BASF Corp.	Emser Industries	Shakespeare Co.
Belding Chemical Industries	Hoechst Celanese	Wellman, Inc.

* Those manufacturers who participated in the SPI monthly report in 1987.

	CAPACITY	UTILIZATION RATE (%)
1977	359	70.8
1978	369	74.5
1979	410	79.8
1980	428	64.0
1981	442	70.6
1982	429	53.1
1983	431	74.5
1984	511	77.5
1985	553	72.2
1986	509	91.4
1987	548	92.5

PRODUCTION AND SALES & CAPTIVE USE

(millions of pounds)

YEAR	PRODUCTION	SALES & CAPTIVE USE
1977	254	250
1978	275	278
1979	327	315
1980	274	271
1981	312	288
1982	228	247
1983	321	329
1984	396	389
1985	399	403
1986	465	443
1987	507	499
Compound Growth Rate		
1977-1987	7.2%	7.2%

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

NYLON

DOMESTIC CONSUMPTION BY END-USE

(in thousands of pounds)

END-USE	1983	1984	1985	1986	1987
Automotive and truck	109,949	147,500	166,232	167,741	158,945
Electrical and Electronic[1]	36,144	45,247	42,286	46,996	58,826
Appliances	6,804	6,752	7,559	6,254	7,722
Film and Coating	40,156	43,014	41,698	46,459	52,763
Wire and Cable	18,733	20,913	21,093	22,269	27,288
Monofilament	15,184	15,283	16,006	20,753	19,924
Consumer[2]	20,187	19,547	20,930	24,604	30,381
Industrial/Machinery	27,853	34,111	31,931	26,600	30,314
Others	30,043	30,978	30,739	41,761	53,070
Total	**305,053**	**363,345**	**378,474**	**403,437**	**439,233**

[1]Includes electrical and electronic applications not assignable to automotive and truck or appliance markets

[2]Includes such items as housewares, brushes, combs, sporting goods, cameras and toys

Source: SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

DISTRIBUTION BY MAJOR MARKET

(in millions of pounds)

MAJOR MARKET	1983	1984	1985	1986	1987
Transportation	109	156	180	192	164
Packaging	40	38	*	*	51
Building and Construction	*	*	*	*	*
Electrical/Electronic	60	73	67	71	94
Furniture and Furnishings	9	6	5	6	10
Consumer and Institutional	*	*	*	31	36
Industrial/Machinery	28	38	32	32	32
Adhesives/Inks/Coatings	*	*	*	*	*
All Other	59	52	95	72	53
Exports	24	26	24	39	59
Total	**329**	**389**	**403**	**443**	**499**

*Included in All Other

Source: SPI Committee on Resin Statistics Annual Major Markets Survey

TYPICAL APPLICATIONS

Electrical connectors
Fender extensions
Brush bristles
Wire jackets
Power tool housings
Fishing line
Emission cannisters
Cooking bags
Sutures

POLYPROPYLENE

MANUFACTURERS*

Amoco Chemical Corp.
Aristech Chemical Co.
Eastman Chemical Products, Inc.
El Paso Chemical Co.
Exxon Chemical Co.
Fina Oil & Chemical
Himont U.S.A.
Phillips Chemical Company
Quantum Chemical Corp.
Shell Chemical Company
Soltex Polymer Corp.

* Those manufacturers who participated in the SPI monthly report in 1987.

	CAPACITY	UTILIZATION RATE (%)
1977	3,330	82.5
1978	4,605	66.8
1979	5,035	76.3
1980	5,194	70.2
1981	5,056	78.2
1982	5,088	68.3
1983	5,272	84.1
1984	5,625	87.8
1985	5,800	88.6
1986	6,162	94.3
1987	6,865	96.8

PRODUCTION AND SALES & CAPTIVE USE

(millions of pounds)

YEAR	PRODUCTION	SALES & CAPTIVE USE
1977	2,747	2,698
1978	3,074	3,055
1979	3,841	3,894
1980	3,648	3,714
1981	3,955	3,888
1982	3,477	3,623
1983	4,434	4,464
1984	4,940	4,816
1985	5,139	5,275
1986	5,812	5,824
1987	6,647	6,720
Compound Growth Rate		
1977-1987	9.2%	9.5%

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

POLYPROPYLENE

DOMESTIC CONSUMPTION BY END-USE

(in millions of pounds)

END-USE	1983	1984	1985	1986	1987
Injection molding, total	1,232	1,290	1,274	1,289	1,647
Appliances	96	121	114	127	141
Consumer products	301	292	310	311	430
Rigid packaging	351	360	387	430	527
Transportation	293	316	340	308	324
All other injection molding	191	201	123	113	225
Blow molding	90	105	105	106	114
Film (10 mils & below)	364	401	389	498	559
Sheet	33	52	44	39	82
Other extruded products (including wire & cable, pipe & conduit, and extrusion coating)	106	112	89	98	126
Fiber & filaments	1,221	1,338	1,433	1,516	1,750
All other uses	618	736	1,066	1,148	1,197
Total	**3,664**	**4,034**	**4,400**	**4,694**	**5,475**

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

DISTRIBUTION BY MAJOR MARKET

(in millions of pounds)

MAJOR MARKET	1983	1984	1985	1986	1987
Transportation	293	233	230	237	276
Packaging	845	901	1,000	1,128	1,450
Building and Construction	22	36	*	*	34
Electrical/Electronic	242	289	273	277	290
Furniture and Furnishings	983	1,123	1,119	1,103	1,255
Consumer and Institutional	580	624	621	732	966
Industrial /Machinery	*	*	11	*	*
Adhesives/Inks/Coatings	*	*	*	*	*
All Other	699	828	1,146	1,217	1,204
Exports	800	782	875	1,130	1,2[illegible]
Total	**4,464**	**4,816**	**5,275**	**5,824**	**6,720**

*Included in All Other

Source: SPI Committee on Resin Statistics Annual Major Markets Survey

TYPICAL APPLICATIONS

Retort pouches
Tobacco wrap
Bottles
Battery cases
Carpet backing
Threaded caps
Filter plates
Toys
Microwave oven containers

POLYSTYRENE

MANUFACTURERS*

A & E Plastics
Amoco Chemical Corp.
ARCO Chemical Co.
Asoma Polymers
BASF Corp.
Chevron Chemical Co.
Dart Polymers
Dow Chemical Corp.
Fina Oil & Chemical
Huntsman Chemical Co.
Mobil Chemical Corp.
Polysar, Inc.
Texstyrene Plastic Co.

*Those manufacturers who participated in the SPI Monthly Statistical Report in 1987

	CAPACITY	UTILIZATION RATE (%)
1977	5,165	66.7
1978	5,034	75.9
1979	5,201	77.0
1980	5,244	67.1
1981	5,161	70.2
1982	5,176	61.7
1983	5,189	68.7
1984	5,365	71.5
1985	5,158	78.6
1986	5,182	86.3
1987	5,221	91.6

PRODUCTION AND SALES & CAPTIVE USE

(millions of pounds)

YEAR	PRODUCTION	SALES & CAPTIVE USE
1977	3,446	3,557
1978	3,823	3,870
1979	4,005	3,997
1980	3,521	3,518
1981	3,621	3,604
1982	3,191	3,200
1983	3,567	3,605
1984	3,838	3,836
1985	4,054	4,108
1986	4,470	4,463
1987	4,780	4,860
Compound Growth Rate		
1977-1987	3.4%	3.2%

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

POLYSTYRENE

DOMESTIC CONSUMPTION BY END-USE

(in millions of pounds)

END-USE	1983	1984	1985	1986	1987
Straight Polystyrene	1,811	1,959	2,078	2,260	2,526
Rubber-Modified Polystyrene	1,718	1,776	1,946	2,088	2,221
Total	**3,529**	**3,735**	**4,024**	**4,348**	**4,747**
Molding	1,516	1,436	1,403	1,540	1,857
Extrusion	1,238	1,468	1,737	1,966	2,105
Expandable Polystyrene Beads	440	487	521	497	523
All Other Uses	335	344	363	345	262
Total Domestic	**3,529**	**3,735**	**4,024**	**4,348**	**4,747**

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

DISTRIBUTION BY MAJOR MARKET

(in millions of pounds)

MAJOR MARKET	1983	1984	1985	1986	1987
Transportation	12	*	*	*	*
Packaging	1,486	1,540	1,292	1,360	1,421
Building and Construction	294	385	449	418	571
Electrical/Electronic	307	351	309	360	460
Furniture and Furnishings	47	26	47	47	40
Consumer and Institutional	820	754	1,090	1,296	1,668
Industrial/Machinery	*	*	*	*	--
Adhesives/Inks/Coatings	*	--	*	*	*
All Other	563	679	837	868	587
Exports	77	101	84	114	113
Total	**3,606**	**3,836**	**4,108**	**4,463**	**4,860**

*Included in All Other

Source: SPI Committee on Resin Statistics Annual Major Markets Survey

TYPICAL APPLICATIONS

Disposable Serviceware	Video cassettes	Business machines
Pallets	Appliance parts	Syringes
Trays	Roofing insulation	Egg cartons

POLYVINYL CHLORIDE

MANUFACTURERS*

Air Products & Chemicals
Borden Chemical Company
CertainTeed Products Corp.
Formosa Plastics
Georgia-Gulf Corp.
B.F. Goodrich Chemical Company
Goodyear Tire & Rubber Company
Keysor-Century Corp.
Occidental Chemical Co.
Shintech, Inc.
Union Carbide Corp.
Vista Chemicals
Vygen

*Those manufacturers who participated in the SPI Monthly Statistical Report in 1987

	CAPACITY	UTILIZATION RATE (%)
1977	6,345	82.8
1978	6,302	90.8
1979	7,093	86.3
1980	7,126	76.8
1981	7,528	75.8
1982	7,389	72.1
1983	7,655	79.2
1984	8,317	81.3
1985	8,355	81.1
1986	8,036	90.3
1987	8,335	95.6

TYPICAL APPLICATIONS

Food wrap
Flooring
Siding
Pipe
Wall covering
Coatings
Upholstery
Garden hose
Shower curtains

PRODUCTION AND SALES & CAPTIVE USE

(millions of pounds)

YEAR	PRODUCTION	SALES & CAPTIVE USE
1977	5,253	5,232
1978	5,723	5,810
1979	6,119	6,138
1980	5,470	5,407
1981	5,707	5,601
1982	5,326	5,455
1983	6,066	6,152
1984	6,760	6,798
1985	6,772	6,720
1986	7,256	7,412
1987	7,971	8,081
Compound Growth Rate		
1977-1987	4.3%	4.4%

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

POLYVINYL CHLORIDE

DOMESTIC CONSUMPTION BY END-USE

(in millions of pounds)

	1983	1984	1985	1986	1987
Calendering, total	**682**	**720**	**690**	**716**	**779**
Flooring	160	173	161	163	188
Textile	105	91	71	79	110
All other calendering	417	456	458	474	481
Coating, total	**361**	**350**	**303**	**330**	**377**
Flooring	149	146	125	144	165
Textile & paper coating	119	107	93	97	110
Protective coatings	45	43	46	48	52
Adhesives & all other coatings	48	54	39	41	50
Extrusion, total	**3,496**	**4,330**	**4,481**	**4,898**	**5,296**
Wire & cable	350	411	455	419	464
Film & sheet	309	350	226	258	348
Rigid pipe & tubing (except fittings)	2,273	2,901	2,809	3,165	3,352
All other extrusions	564	668	991	530	504
Siding, siding accessories & mobile homes & skirts	NA	NA	NA	526	628
Molding, total	**430**	**464**	**465**	**495**	**515**
Bottles	166	186	163	188	176
Sound records	80	75	68	54	NA
Fittings (rigid pipe & tubing)	106	122	160	141	161
All other molding	78	81	74	112	178
Paste processes (except coating), total	**166**	**169**	**156**	**156**	**167**
Plastisol formulation	96	93	77	76	88
All other	70	76	79	80	79
Resellers & Compounders	**203**	**167**	**101**	**332**	**361**
All other uses	**280**	**220**	**233**	**115**	**155**
Grand Total	**5,618**	**6,420**	**6,429**	**7,042**	**7,650**

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

DISTRIBUTION BY MAJOR MARKET

(in millions of pounds)

MAJOR MARKET	1983	1984	1985	1986	1987
Transportation	150	163	141	149	*
Packaging	546	619	572	497	614
Building and Construction	3,329	4,134	4,198	4,711	5,056
Electrical/Electronic	386	398	479	478	524
Furniture and Furnishings	289	242	310	380	292
Consumer and Institutional	293	290	230	277	265
Industrial/Machinery	20	19	30	17	*
Adhesives/Inks/Coatings	77	108	89	83	110
All Other	528	447	379	450	790
Exports	534	378	292	370	430
Total	**6,152**	**6,798**	**6,720**	**7,412**	**8,081**

Source: SPI Committee on Resin Statistics Annual Major Markets Survey

*Included in All Other NA = Not Available

POLYVINYL ACETATE

Polyvinyl acetate is produced by the emulsion polymerization of vinyl acetate to yield a water emulsion with a solids content of 50-55%. Commercial exploitation of this polymer began in the early 1930's, although its discovery dates from the early 1900's. Early production of the resin was primarily as a homopolymer, but more recently resin properties have been changed by including comonomers as n-butyl acrylate, 2-ethylhexyl-acrylate, ethylene, dibutylmaleate, and dibutylfumarate. Because of the large number of polyvinyl acetate producers, the numerous copolymers included and the variety of physical forms, polyvinyl acetate production is reported to SPI in terms of vinyl acetate monomer sold to or used by the polymerizer.

Polyvinyl acetate resins are primarily used in aqueous emulsions and find utility in adhesives, paints, textile finishes, and paper coating applications. A typical example of a polyvinyl acetate emulsion is the "white glue" used in many homes and schools.

There are more than 50 producers of polyvinyl acetate, supplied with monomer by such companies as Air Products & Chemicals, Borden, Hoechst Celanese, H.B. Fuller, W.R. Grace, Monsanto, National Starch, Reichhold Chemicals, Rohm & Haas, Union Carbide, Union Chemical, and U.S. Industrial Chemicals, Division of Quantum Chemical Co.

SALES AND CAPTIVE USE OFVINYL ACETATE MONOMER

FOR POLYVINYL ACETATE

(thousands of pounds)

Year	Emulsion Paint	Adhesives	Paper	Textile	Non-woven Binders	Others	Export	Total
1983	210,553	273,751	117,330	22,601	31,212	27,542	5,867	688,856
1984	203,282	275,002	119,528	25,924	30,896	28,767	6,976	690,375
1985	204,497	262,437	110,969	31,964	NA	58,185	6,124	674,176
1986	233,730	254,056	110,001	32,027	NA	56,340	3,964	690,118
1987	236,501	249,763	121,823	34,130	NA	59,961	6,596	708,774

COMPOUND GROWTH RATE

TOTAL SALES & CAPTIVE USE

1984-1985	-0.1%
1985-1986	2.4%
1986-1987	2.7%

NA = Not Available

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

OTHER VINYL RESINS

Vinyl resins included in this category are polyvinyl butyral, polyvinyl formal, and polyvinylidene chloride and their respective copolymers containing at least 50% of the base resin.

Polyvinyl butyral and polyvinyl formal are prepared by reacting polyvinyl alcohol with butyraldhyde or formaldehyde in the presence of a strong mineral acid. There are many grades of these products in use, differing in degree of hydroxyl substitution and molecular weight. The largest end of polyvinyl butyral is as the adhesive film in the lamination of auto safety glass. The major use of polyvinyl formal is in magnet wire coatings.

Polyvinylidene chloride is prepared by suspension or emulsion polymerization of vinylidene chloride. It finds major application as a film or as a coating on flexible substrates for packaging food products where oxygen impermeability and oil resistance are important.

Producers of these vinyl resins include Dow, DuPont, W.R. Grace, Monsanto, Morton Industries, Rohm and Haas, and Union Carbide, Union Chemical.

PRODUCTION AND SALES & CAPTIVE USE

(thousands of pounds)

YEAR	PRODUCTION	SALES & CAPTIVE USE
1983	185,558	177,844
1984	187,209	186,619
1985	189,699	191,437
1986	194,924	180,357
1987	212,314	203,643

GROWTH RATE OF SALES & CAPTIVE USE

1984-1985	2.6%
1985-1986	-5.8%
1985-1987	3.2%

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

DOMESTIC SALES & USE

SELECTED THERMOPLASTICS BY PROCESS GRADE

(millions of pounds)

MATERIAL/YEAR	TOTAL	INJECTION MOLDING	EXTRUSION	BLOW MOLDING	OTHER
Grand Total					
1982	23,259	4,979	11,665	2,383	4,232
1983	26,546	5,778	13,407	2,620	4,741
1984	29,007	5,849	14,918	2,948	5,292
1985	30,407	6,052	15,526	3,182	5,647
1986	N.C.	N.C.	N.C.	N.C.	N.C.
1987	N.C.	N.C.	N.C.	N.C.	N.C.
LD Polyethylene					
1982	6,543	507	5,118	42	876
1983	7,127	657	5,628	42	800
1984	7,442	612	5,819	43	968
1985	7,660	583	5,894	47	1,136
1986	7,859	575	6,487	39	758
1987	8,609	697	7,110	54	748
Growth Rate					
1982-1987	5.8%	6.5%	7.0%	5.2%	-3.1%
HD Polyethylene					
1982	4,347	1,102	898	1,714	633
1983	4,706	1,188	1,076	1,808	634
1984	5,253	1,191	1,133	2,079	850
1985	5,774	1,538	1,204	2,245	787
1986	6,103	1,550	1,275	2,400	878
1987	7,272	1,780	1,641	2,884	967
Growth Rate					
1982-1987	11.0%	10.0%	12.9%	11.0%	8.9%
Polypropylene					
1982	2,885	1,073	1,268	68	476
1983	3,664	1,232	1,724	90	618
1984	4,034	1,290	1,903	105	736
1985	4,400	1,274	1,955	105	1,066
1986	4,694	1,289	2,152	106	1,147
1987	5,475	1,647	2,517	114	1,197
Growth Rate					
1982-1987	13.8%	9.0%	14.6%	11.0%	20.0%
ABS[a]					
1982	689	430	111	---	148
1983	900	560	145	---	195
1984	1,000	600	150	---	250
1985	900	575	125	---	200
1986	1,080	NA	NA	---	NA
1987	1,208	NA	NA	---	NA
Growth Rate					
1982-1987	11.9%	---	---	---	---

Source: Monthly Statistical Report, SPI Committee on Resin Statistics as compiled by Ernst & Whinney

N.C. = Not comparable, reporting changes in 1986 NA = Not Available [a] ABS estimated 1983-1985

DOMESTIC SALES & USE

SELECTED THERMOPLASTICS BY PROCESS GRADE (Cont'd)

(millions of pounds)

MATERIAL/YEAR	TOTAL	INJECTION MOLDING	EXTRUSION	BLOW MOLDING	OTHER
Polystyrene					
1982	3,105	1,368	1,060	---------	677
1983	3,529	1,516	1,238	---------	775
1984	3,735	1,436	1,468	---------	831
1985	4,024	1,403	1,737	---------	884
1986	4,348	1,540	1,966	---------	842
1987	4,747	1,857	2,105	---------	785
Growth Rate					
1982-1987	8.9%	6.2%	14.8%	---------	3.0%
Nylon					
1982	229	138	71	---------	20
1983	305	198	85	---------	22
1984	363	243	95	---------	25
1985	378	251	100	---------	27
1986	403	266	112	---------	25
1987	439	267	131	---------	41
Growth Rate					
1982-1987	13.8%	14.1%	13.0%	---------	15.1%
Thermoplastic Polyester[b]					
1982	571	100	10	456	5
1983	697	163	15	514	5
1984	760	200	20	535	5
1985	842	190	25	622	5
1986	NA	NA	NA	NA	NA
1987	NA	NA	NA	NA	NA
Growth Rate					
1982-1987	NA	NA	NA	NA	NA
P V C					
1982	4,890	261	3,129	103	1,397
1983	5,618	264	3,496	166	1,692
1984	6,420	277	4,330	186	1,627
1985	6,429	228	4,481	163	1,557
1986	7,042	306	4,899	189	1,649
1987	7,650	339	5,296	176	1,839
Growth Rate					
1982-1987	9.2%	5.3%	11.1%	11.0%	5.7%

Source: Monthly Statistical Report, SPI Committee on Resin Statistics as compiled by Ernst & Whinney

NA = Not Available. [b]Thermoplastic Polyester estimated 1983-1985.

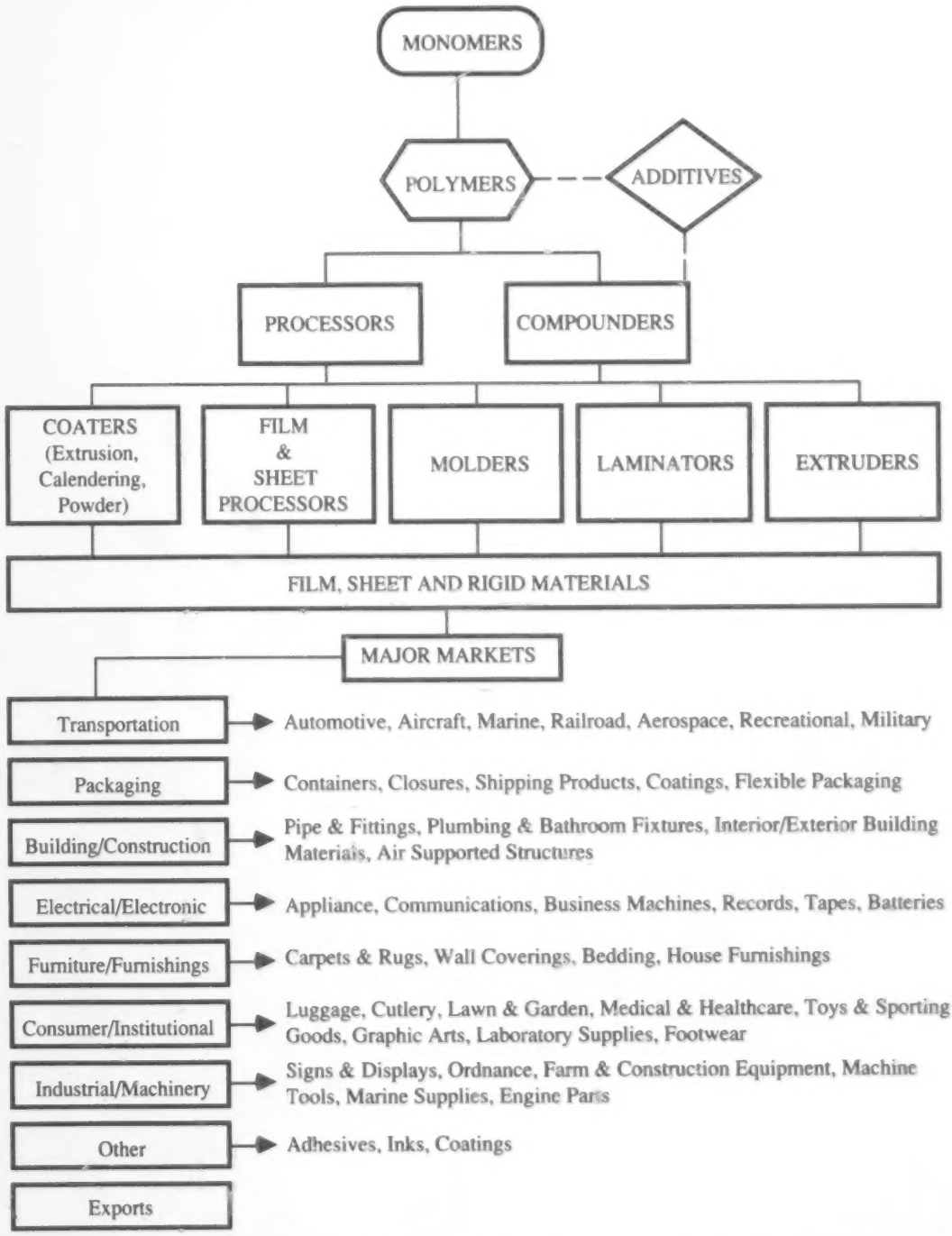
The Society of the Plastics Industry, Inc.

Fabricated Plastic Products

Fabricated Plastic Products

FLOW CHART:

FROM RAW MATERIAL TO FINISHED PRODUCT



Source: SPI Committee on Resin Statistics, Major Markets Manual

REINFORCED PLASTICS

The combination of thermosetting unsaturated polyester resins with glass fiber accounts for the bulk of reinforced plastics products. Phenolics, vinyl esters, epoxies and fumarate resins bring thermosets' share of the market to almost 90%. The thermoplastics which account for the remainder, in general relative importance, are polyolefins, nylon, polycarbonate, styrenics, and polyvinyl chloride.

Random glass fibers are the volume reinforcement, but beads, flake, and woven mat and roving are other forms in which the shafts, carbon and graphite or certain synthetic fibers have a growing use experience. By weight the reinforcement is usually 25-35%, but 50% is not unusual in spray-up or press-molded materials.

Thermoset materials have been the choice for impact-strength, higher resistance to heat distortion, and resistance to corrosive environments. Thermoplastics are developing where large runs of uniform parts are a requirement, and where relatively smaller size of the parts makes processing feasible. In the last two years the reinforcement of foamed parts has become a reality in several markets.

Reinforced plastics production at the outset, during World War II, was almost entirely for military use such as in radomes. In recent years the marine market has dominated consumption, but even though its projected growth is 75% over the next five years it will probably soon take second place to transportation. The use of RP in automobiles could double over the next four years. The other high-volume growth market in the immediate future is chemical-resistance and pipeline application. All of the use categories for reinforced plastics are slated for faster growth than the economy generally.

The reinforced plastics industry enjoys a high level of technical activity because of the engineered nature of its products, and the relatively high value-added nature of the finished product. The search for new applications is vigorous, while new levels of performance in existing uses are continually being refined. Environmental and health concerns about styrene monomer, as well as continued demands of fire-retardant and non-toxic materials, suggest that research on basic resin characteristics will also continue.

The structure of the reinforced plastics industry has stablized in recent years. Several materials suppliers have, in the pattern of other domestic industries, "integrated forward" by acquiring or developing fabrication divisions which specialize in a given manufacturing process or market, such as panels for light construction, corrosion-resistant equipment, or sanitaryware. More common, however, has been the development by large corporations identified with a given market, such as industrial pipe, automotive parts, or marine equipment, of a "captive" reinforced plastics operation which complements or replaces their metal or woodworking manufacturing. In the last decade custom molders have attempted to stabilize their role by selecting to produce several types of parts which they handle especially well, but spreading these selections over several market areas to minimize uneven business cycles. There have, of course, emerged large and small manufacturing companies who independently specialize in a given process or product. To complete the picture of the RP industry's diversity, we must mention that there is still room for the inventor/entrepreneur and, at the other end of the development process, there continues to be a considerable degree of university and laboratory research.

REINFORCED PLASTICS SHIPMENTS BY MARKET

(both thermoset & thermoplastic resins)

MARKETS	1982	1983	1984	1985[1]	1986[1]	1987[2]
Aircraft & Aerospace	22	25	29	32	37	40
Applicances & Equipment	82	106	123	133	136	141
Construction	312	400	430	445	456	464
Consumer Goods	84	128	143	142	149	152
Corrosion-Resistant Products	235	288	310	295	291	300
Electrical Rods, Tubes, Parts	140	170	189	191	201	208
Marine Accessories	230	276	309	335	340	351
Land Transportation	359	458	540	563	585	608
Miscellaneous	64	72	80	82	83	85
Total	**1,528**	**1,923**	**2,153**	**2,218**	**2,278**	**2,349**

[1] = Estimate [2] = Forecast

Source: Reinforced Plastics/Composites Institute, SPI

Fabricated Plastic Products

PLASTIC BOTTLES

SHIPMENTS

(in millions of units)

BY MARKET	1984[a]	1985[R]	1986[R]	1987[1]
Household Chemicals	3,840	3,990	4,115	4,367
Industrial Chemical	396	391	433	446
Automotive & Marine	1,738	1,953	2,179	2,271
Toiletries & Cosmetics	2,774	2,920	2,974	3,025
Medicinal & Health	3355	3,620	3,925	4,065
Food				
Milk	5,028	5,258	5,494	5,804
Other food	1,073	1,306	1,837	2,535
Beverages				
Carbonated Soft Drinks	4,630	5,430	6,580	7,962
Other beverages	1,147	1,238	1,542	2,159
Other	1,407	1,417	1,411	1,425
Total	**25,388**	**27,523**	**30,490**	**34,059**

EXPLANATION OF TERMS

Household Chemicals - Bleach, dishwashing, laundry, and other detergents; fabric softeners; bowl and drain cleaners; dry cleansers; floor care products; soaps (including medicated); window cleaners; air fresheners, household pesticides and garden chemicals; household adhesives; waxes and polishes (including car polish); car wax, wax and polish remover, etc.

Industrial, Agricultural and Speciality Chemicals - Agricultural, industrial, and institutional chemical and cleaning products; photographic chemicals; battery acid; paint and varnish supplies, etc.

Toiletries and Cosmetics - shampoos and other hair grooming products; talcs and powders; hand, face, and body lotions and ointments; shaving preparations; bath products; perfumes, toilet water, and colognes; personal deodorant, etc.

Medicinal and health - Oral antisceptics and mouthwashes; laxatives; pharmaceutical lotions, creams, and ointments; pain relievers; vitamins; rubbing alcohols; antacids, etc.

Food and Beverages - Milk, carbonated beverages; noncarbonated beverages such as juices, water, cider, etc.; distilled spirits and other alcoholic beverages; edible oil; and all other food items.

Automotive and Marine - Antifreeze; motor oil; lubricants; defrosters; windshield cleaners; hydraulic fluids; additives, etc.

SHIPMENTS

(in millions of units)

BY MARKET	1984[a]	1985[R]	1986[R]	1987[1]
LD Polyethylene	97.1	109.0	138.0	152.0
HD Polyethylene	1637.0	1760.0	1,974.4	2,083.0
Polyvinyl Chloride	130.0	163.0	189.0	204.1
Polypropylene	85.0	102.5	115.0	130.0
Polyethylene Terephthalate	535.0	621.2	730.0	895.0
Polystyrene & Other	41.0	42.4	47.1	42.3
Total	**2,525.1**	**2,798.1**	**3,193.5**	**3,506.4**

[1] = Estimate [R] = Revised

Source: U.S. Department of Commerce; Census & ITA

The Society of the Plastics Industry, Inc.

Processing and Machinery

PROCESSING METHODS

INJECTION MOLDING

Injection molding is the principal method of forming thermoplastic materials. Modifications of the injection process are sometimes used for thermosetting plastics.

In injection molding, plastic material is put into a hopper which feeds into a heating chamber. A plunger pushes the plastic through this long heating chamber where the material is softened to a fluid state. At the end of this chamber there is a nozzle which abuts firmly against an opening into a cool, closed mold. The fluid plastic is forced at high pressure through this nozzle into the cold mold. As soon as the plastic cools to a solid state, the mold opens and the finished plastic is ejected from the press.

The problem with injection molding of thermosetting materials is that, under heat, these plastics will first soften, then harden to an infusible state. Thus it is essential that no softened thermosetting material in the heating chamber be allowed to remain there long enough to set. Jet molding, offset molding and molding using a screw-type machine overcome this problem by liquefying the thermosetting plastic material just as it goes through the injection nozzle into the mold, but not before.

BLOW MOLDING

Blow molding is a method of forming used with thermoplastic materials.

Basically, blow molding consists of stretching and then hardening a plastic against a mold. There are two general methods of doing this type of thermoplastic molding: the direct method and the indirect method, encompassing several variations of each.

In the direct method, a glob of molten thermoplastic material is formed into the rough shape of the desired finished product. This shape is then inserted in a female mold and air blown into the plastic, as into a balloon, to force it against the sides of the mold. The formed material is then cooled before removal from the mold.

In the indirect method, a thermoplastic sheet or special shape is first heated, then clamped between a die and cover. Air pressure forced between the plastic and the cover forces the material into contact with the die, which has the contour desired in the finished product. The plastic is cooled before removal from contact with the die.

COMPRESSION MOLDING

Compression molding is the most common method of forming thermosetting materials. It is not generally used for thermoplastics.

Compression molding is simply the squeezing of a material into a desired shape by application of heat and pressure to the material in a mold.

Plastic molding powder, mixed with such materials or fillers as woodflour and cellulose to strengthen or give other added qualities to the finished product, is put directly into the open mold cavity. The mold is then closed, pressing down on the plastic and causing it to flow throughout the mold. It is while the heated mold is closed that the thermosetting material undergoes a chemical change which permanently hardens it into the shape of the mold. The three compression molding factors -- pressure, temperature and time the mold is closed -- vary with the design of the finished article and the material being molded.

EXTRUSION

Extrusion molding is the method employed to form thermoplastic materials into continuous sheeting, film, tubes, rods, profile shapes, filaments, and to coat wire, cable and cord.

In extrusion, dry plastic material is first loaded into a hopper, then fed into a long heating chamber through which it is moved by the action of a continuously revolving screw. At the end of the heating chamber the molten plastic is forced out through a small opening or die with the shape desired in the finished product. As the plastic extrusion comes from the die, it is fed onto a conveyor belt where it is cooled, most frequently by blowers or by immersion in water.

In the case of wire and cable coating, the thermoplastic is extruded around a continuing length of wire or cable which, like the plastic, passes through the extruder die. The coated wire is wound on drums after cooling.

In producing wide film or sheeting, the plastic is extruded in the form of a tube. This tube may be split as it comes from the die and then stretched and thinned to the dimensions desired in the finished film.

In a different process, the extruded tubing is inflated as it comes from the die, the degree of inflation of the tubing regulating the thickness of the final film.

THERMOFORMING

Thermoforming of plastic sheet has developed rapidly in recent years. Basically, this process consists of heating thermoplastic sheet to a formable plastic state and then applying air and/or mechanical assists to shape it to the contours of a mold.

Air pressure may range from almost zero to several hundred psi *. Up to approximately 14 psi (atmospheric pressure), the pressure is obtained by evacuating the space between the sheet and the mold in order to utilize this atmospheric pressure. This range, known as *vacuum forming*, will give satisfactory reproduction of the mold configuration in the majority of forming applications.

* psi= pounds per square inch.

TRANSFER MOLDING

Transfer molding is most generally used for thermosetting plastics.

This method is like compression molding in that the plastic is cured into an infusible state in a mold under heat and pressure. It differs from compression molding in that the plastic is heated to a point of plasticity before it reaches the mold and is forced into a closed mold by means of an hydraulically-operated plunger.

Transfer molding was developed to facilitate the molding of intricate products with small deep holes or numerous metal inserts. The dry mold compound used in compression molding sometimes disturbs the position of the metal inserts and the pins which form the holes. The liquified plastic material in transfer molding flows around these metal parts without causing them to shift position.

REACTION INJECTION MOLDING

Reaction injection molding (RIM) is a relatively new processing technique that has rapidly taken its place alongside more traditional methods. Unlike liquid casting, the two liquid components, polyols and isocyanates, are mixed in a chamber at relatively low temperatures (75° - 140°) before injection into a closed mold. An exothermic reaction occurs and consequently RIM requires far less energy usage than any other injection molding system.

The three major types of polyurethane RIM systems are rigid structural foam, low-modulus elastomers, and high-modulus elastomers.

Reinforced RIM (R-RIM) consists in the addition of such materials as chopped or milled glass fiber to the polyurethane to enhance stiffness and to increase modulus thus expanding the range of applications.

DOLLAR SALES *

PLASTICS MACHINERY

(in millions of dollars)

MACHINE TYPE	1983	1984a	1985	1986	1987
Injection Molding	298.0	457.0	376.0	315.0	257.1
Structural Foam	4.5	4.5	4.5	3.9	3.9
Extrusion, single screw	85.0	137.0	84.5	121.0	112.5
Extrusion multi screw	18.5	22.0	16.0	14.5	15.6
Blow Molding	120.0	105.0	65.0	80.0	70.0
Thermoforming	33.0	44.0	50.0	55.0	60.0
Reaction-Injection Molding	8.0	10.0	7.5	6.0	6.8
Compression	17.0	16.5	13.0	13.5	16.2
Expanded Bead	8.0	8.0	1.0	0.5	0.5
Transfer Molding	5.5	5.5	4.5	5.0	7.1
Total	**597.5**	**809.5**	**622.0**	**614.4**	**549.7**

* Includes exports; does not include imports
a = Revised from 1985 edition
Source: Modern Plastics Magazine

SHIPMENTS

SINGLE SCREW EXTRUSION MACHINERY

(in number of units)

SCREW DIAMETER	1983	1984a	1985	1986	1987
Up to But Not Including 2"	168	184	156	172	154
2" Up to But Not Including 2 1/2"	126	168	115	114	117
2 1/2" Up to But Not Including 3"	163	267	235	212	223
3" Up to But Not Including 4"	165	198	216	213	253
4" Up to But Not Including 5 1/2"	85	181	140	134	159
5 1/2" Up to But Not Including 7 1/2"	60	106	76	75	62
Includes 7 1/2" & Larger	5	12	16	5	14
Total	**772**	**1,116**	**954**	**925**	**982**

a = Revised from 1985 edition
Note: Includes domestic shipments and exports
Source: SPI Machinery Division

SHIPMENTS

INJECTION MOLDING MACHINERY

(in number of units)

CLAMP FORCE (Tons)	1983	1984	1985	1986	1987
Domestic Shipments					
0-199	848	1,239	a	608	a
200-299	363	485	1,316	280	939
300-399	b	484	411	c	c
400-499	b	c	b	c	c
500-599	543	c	280	c	c
600-749	c	c	c	c	c
750-1199	c	c	c	c	c
1200-1999	c	c	c	c	c
2000 and Over	106	402	246	739	690
Total	1,384	2,610	2,253	1,627	1,629
Export Shipments					
0-199	34	39	a	40	a
200-299	12	22	44	15	52
300-399	b	22	12	c	c
400-499	b	c	b	c	c
500-599	14	c	9	c	c
600-749	c	c	c	c	c
750-1199	c	c	c	c	c
1200-1999	c	c	c	c	c
2000 and Over	2	12	14	27	67
Total	62	95	79	82	119
Total Shipments					
0-199	882	1,278	a	648	a
200-299	375	507	1,360	295	991
300-399	b	506	423	c	c
400-499	b	c	b	c	c
500-599	557	c	289	c	c
600-749	c	c	c	c	c
750-1199	c	c	c	c	c
1200-1999	c	c	c	c	c
2000 and Over	108	414	260	766	757
Grand Total	**1,922**	**2,705**	**2,332**	**1,709**	**1,748**

[a] Combined with 200-299

[b] Combined with 500-599

[c] Combined with 2000 and over

Source: SPI Machinery Division

The Society of the Plastics Industry, Inc.

Glossary

Glossary

ADDITIVES FOR PLASTICS

ADDITIVE LUBRICANTS

These materials are added to plastics to assist flow in calendering, molding and extrusion by lubricating the metal surfaces in contact with the plastic. They also assist in knitting and wetting of the resin in mixing and milling operations. To be effective, lubricants must be compatible with the resins in which they are used, must not adversely affect the properties of end-products, and must be easily combined.

Examples: stearic acid, waxes, fatty acid esters, fatty acid amines.

ANTIOXIDANTS

They inhibit the oxidation of materials exposed to air or oxygen at normal or elevated temperatures. They are used in plastics which are subject to oxidative degradation, such as polyolefins, ABS, polystyrene, acetal and polyphenylene oxide.

Examples: alkylated phenols, amines, organic phosphites and phosphates, esters.

ANTISTATS

Chemicals which impart a slight to moderate degree of electrical conductivity to plastics compounds, thus preventing the accumulation of electrostatic charges on finished articles. They may be incorporated in the material before molding, or applied to their surfaces after molding. They function either by being inherently conductive or by absorbing moisture from the air.

Examples: quaternary ammonium compounds, anionics, amines.

BLOWING AGENTS (FOAMING AGENTS)

Substances which alone or in combination with other substances are capable of producing a cellular structure in a plastic or rubber mass. Thus, the term includes compressed gases which expand when pressure is released, soluble solids that leave pores when leached out, liquids that develop cells when they change to gases, and chemical agents that decompose or react under the influence of heat to form a gas.

Examples: azodicarbonamide, modified azos, OBSH, HTBA.

COLORANTS

Dyes or pigments which impart color to plastics. The dyes are synthetic or natural compounds of submicroscopic or molecular size, soluble in most common solvents, yielding perfectly transparent colors. The pigments are organic and inorganic substances with larger particle sizes and usually insoluble in the common solvents. Colorants are added to plastics by dry coloring (tumbling the colorant with the base or compounded resin); by extrusion coloring (extruding a dry colored mixture and chopping it into pellets to be reprocessed); by masterbatching; or by stirring colorants or dispersions thereof into liquid plastisols or resin systems.

Examples: titanium dioxide, iron oxides, anthraquinones, carbon black.

Glossary

FLAME RETARDANTS

Materials that reduce the tendency of plastic articles to burn. They are usually incorporated as additives during compounding, but sometimes are applied to surfaces of finished articles.

Examples: antimony trioxide, chlorinated paraffins, bromophenols.

HEAT STABILIZERS

Agents used in compounding some plastics to assist in maintaining the physical and chemical properties of the compounded materials at suitable values throughout the processing and service life of the material and/or the parts made therefrom. They protect plastics from the effects of heat such as changes in color decrease in mechanical and electrical properties, and undesirable surface conditions.

Examples: lead, barium-cadmium, tin, calcium-zinc.

ORGANIC PEROXIDES

Thermally decomposable compounds which can initiate polymerization reactions and effect cross-linking upon decomposition. The rate of decomposition can be controlled by means of promoters or accelerators added to the system to increase the decomposition rate; or by inhibitors when it is desired to retard the decomposition.

Examples: MEK peroxide, benzoyl peroxide, alkyl peroxide, peresters.

PLASTICIZERS

Materials incorporated in a plastic or elastomer to increase its flexibility, workability or distensibility. Most plasticizers are nonvolatile organic liquids or low-melting point solids, which function by reducing the normal intermolecular forces in a resin thus permitting the macromolecules to slide over one another more freely.

Examples: adipates, azelates, trimellitates, DOP/DIOP/DIDP.

ULTRAVIOLET STABILIZERS (UV LIGHT ABSORBERS)

Chemical agents which absorb or screen out radiation beyond the violet end of the spectrum of visible radiations. Such radiation has sufficient energy to initiate reactions leading to the degradation of many plastics. These agents are often combined with other additives, e.g. heat stabilizers and antioxidants, with which they act in synergistic fashion.

Examples: benzophenones, benzotriazole, salicylates.

Source: Whittington's Dictionary of Plastics

DEFINITIONS OF RESINS

ACETAL

An engineering thermoplastic produced by the polymerization of purified formaldehyde [CH_2O] into both homopolymer and copolymer types. Typical applications are found in consumer products, automotive parts, and industrial machinery parts.

ACRYLICS

A family of thermoplastic resins of acrylic esters [$CH_2CHCOOR$] or methacrylic esters [$CH_2C(CH_3)COOR$]. The acrylates may be methyl, ethyl, butyl, or 2-ethylhexyl. Usual methacrylates are the methyl, ethyl, butyl, laural and stearyl. Typical applications are found in lighting fixtures, glazing and automotive parts.

ACRYLONITRILE BUTADIENE STYRENE

A class of thermoplastic terpolymers including a range of resins, all prepared with usually more than 50% styrene [$C_6H_5CHCH_2$] and varying amounts of acrylonitrile [CH_2CHCN] and butadiene [$CH_2CHCHCH_2$]. The three components are combined by a variety of methods involving polymerization, graft copolymerization, physical mixtures and combinations thereof. Typical applications are found in appliances, automotive parts, pipe, business machine and telephone components.

ALKYDS

Thermosetting unsaturated polyester resins produced by reacting an organic alcohol with an organic acid, dissolved in and reacted with unsaturated monomers such as styrene [$C_6H_5CHCH_2$], diallyl phthalate [$C_6H_4(COOCH_2CHCH_2)_2$], diacetone acrylamide [$CH_3COCH_2C(CH_3)_2CHCHCONH_2$] or vinyl toluene [$CH_2CHC_6H_4CH_3$]. Typical applications are found in electrical uses, automotive parts, and as coatings.

CELLULOSICS

A family of thermoplastic resins manufactured by chemical modification of cellulose [$(C_6H_{10}O_5)_n$]. Included are: *cellophane*--regenerated cellulose made by mixing cellulose xanthate [ROCSSH] with a dilute sodium hydroxide [NaOH] solution to form a viscose, then extruding the viscose into an acid bath for regeneration; *cellulose acetate*--an acetic acid ester [$CH_3COOC_2H_5$] of cellulose; *cellulose acetate butyrate*--a mixed ester produced by treating fibrous cellulose with butyric acid [$CH_3CH_2CH_2COOH$], butyric anhydride [$(CH_3CH_2CH_2CO)_2O$], acetic acid [CH_3COOH] and acetic anhydride [$(CH_3CO)_2O$] in the presence of sulfuric acid [H_2SO_4]; *cellulose propionate*-- formed by treating fibrous cellulose with propionic acid [$CH_3CH_2CO_2H$] and acetic acid and anhydrides in the presence of sulfuric acid; *cellulose nitrate*--made by treating fibrous cellulosic materials with a mixture of nitric [HNO_3] and sulfuric acids. Typical applications are found in packaging, consumer products, and automotive parts.

COUMARONE-INDENE

Thermoplastic resin obtained by heating mixtures of coumarone [C_8H_6O] and indene [$C_6H_4CH_2CHCH$] with sulfuric acid [H_2SO_4] to promote polymerization. These resins have no commercial applications when used alone. They are used primarily as processing aids, extenders and plasticizers with other resins in asphalt floor tile.

Glossary

DIALLYL PHTHALATE(DAP)

The term DAP is used both for the monomeric and polymeric forms. The monomer [$C_6H_4(COOCH_2CHCH_2)_2$] is used as a cross-linking agent in unsaturated polyester resins. As a polymer, it is used in the production of thermosetting molding powders, casting resins and laminates.

EPOXY

Thermosetting resins, that, in the uncured form, contain one or more reactive epoxide or oxirane groups.

These epoxide groups serve as cross-linking points in the subsequent curing step, in which the uncured epoxy is reacted with a curing agent or hardener. Cross-linking is accomplished through the epoxide groups as well as through hydroxyl groups that may be present. Most conventional unmodified expoxy resins are produced from epichlorohydrin (chloropropylene oxide) [CH_2OCHCH_2Cl] and bisphenol A[$(CH_3)_2C(C_6H_4OH)_2$]. The other types of epoxy resins are phenoxy resins, novolac resins, and cycloaliphatic resins. Epoxy resins are used as protective coatings, bonding adhesives, in building and construction, and electrical uses, plus many other uses.

FLUOROPOLYMERS

A family of thermoplastic resins analogous to polyethylene in which some of the hydrogen atoms attached to the carbon chain are replaced by fluorine or fluorinated alkyl groups. In some cases, other halogens such as chlorine are also part of the molecule. The most common commercial fluoropolymers are: *FEP* (fluorinated ethylene-propylene) from tetrafluoroethylene [C_2F_4] and hexafluoropropylene [C_3F_6]; *PTFE* (polytetrafluoroethylene) from the polymerization of tetrafluoroethylene and ethylene [C_2H_4]; *PFA* (perfluoro-alkoxy) from tetrafluoroethylene and perfluoropropyl vinyl ether [$C_3H_7C_4OF_5$]; *PCTFE* (polychlorotrifluoro-ethylene) from chlorotrifluoro-ethylene monomer [C_2F_3Cl]; *CTFE-VDF* (polychlorotrifluoroethylenevinylidene fluoride) from chlorotrifluoroethylene and vinylidene fluoride [$C_2H_2F_2$]; *E-CTFE* (polyethylene-chlorotrifluoroethylene) from chlorotrifluoroethylene and ethylene; *PVDF* (polyvinylidene fluoride) from vinylidene fluoride monomer; and, *PVF* (polyvinyl fluoride) from vinyl fluoride monomer [C_2H_3F]. Typical applications for fluoropolymers are found in electrical/electronic uses and pipe and chemical processing equipment.

MELAMINE-FORMALDEHYDE

Thermosetting resins formed by the condensation reaction of formaldehyde [HCHO] and melamine [$C_3N_3(NH_2)_3$]. The chemistry is analogous to that of urea-formaldehyde except that the three amino groups of melamine provide more possibilities for cross-linking, are more highly reactive, and all six hydrogen atoms of melamine will react, forming the hexamethyl compound. Typical applications are found in bonding and adhesives, coatings, and consumer products.

Glossary

NITRILE RESINS

Thermoplastic resins composed of acrylonitrile [CH_2CHCN] along with comonomer such as acrylates, methacrylates, butadiene [$CH_2CHCHCH_2$] and styrene [$C_6H_5CHCH_2$]. Both straight copolymers and copolymers grafted onto elastomeric backbones are available. The unique property of these materials is outstanding resistance to passage of gases and water vapor, making them useful in packaging applications.

NYLON

A generic name for a family of long-chain polyamide engineering thermoplastics which have recurring amide groups [-CO-NH-] as an integral part of the main polymer chain. Nylons are synthesized from intermediates such as dicarboxylic acids, diamines, amino acids and lactams, and are identified by numbers denoting the number of carbon atoms in the polymer chain derived from specific constituents, those from the diamine being given first. The second number, if used, denotes the number of carbon atoms derived from a diacid. Commercial nylons are as follows: *nylon* 4 (polypyrrolidone)-a polymer of 2-pyrrolidone [$CH_2CH_2CH_2C(O)NH$]; *nylon* 6 (polycaprolactam)-made by the polycondensation of caprolactam[$CH_2(CH_2)_4NHCO$]; *nylon* 6/6-made by condensing hexamethylenediamine [$H_2N(CH_2)_6NH_2$] with adipic acid [$COOH(CH_2)_4COOH$]; *nylon* 6/10-made by condensing hexamethylenediamine with sebacic acid[$COOH(CH_2)_8COOH$]; *nylon* 6/12-made from hexamethylenediamine and a 12-carbon dibasic acid; *nylon* 11-produced by polycondensation of the monomer 11-amino-undecanoic acid [$NH_2CH_2(CH_2)_9COOH$]; *nylon* 12-made by the polymerization of laurolactam [$CH_2(CH_2)_{10}CO$)or cyclododecalactam, with 11 methylene units between the linking -NH-CO- groups in the polymer chain. Typical applications for nylons are found in automotive parts, electrical/electronic uses, and packaging.

PETROLEUM RESINS

Thermoplastic resins obtained from a variable mixture unsaturated monomers recovered as byproduct from cracked and distilled petroleum streams. They also contain indene [$C_6H_4CH_2CHCH$], which is copolymerized with a variety of other monomers including styrene [$C_6H_5CHCH_2$], vinyl toluene [$CH_2CHC_6H_4CH_3$], and methyl indene [$C_6H_3CH_3CH_2CHCH$]. Typical applications are found in adhesives, printing inks, rubber compounding, and surface coatings.

PHENOLIC

These thermosetting resins are credited with being the first commercialized wholly synthetic polymer or plastic. The basic raw materials are formaldehyde [HCHO] and phenol [C_6H_5OH], although almost any reactive phenol or aldehyde can be used. The phenols used commerically are phenol, cresols [$CH_3C_6H_4OH$], xylenols [$(CH_3)_2C_6H_3OH$], p-t-butylphenol [$C_4H_9C_6H_4OH$], p-phenylphenol [$C_6H_5C_6H_4OH$], bisphenols [$(C_6H_4OH)_2$], and resorcinol [$C_6H_4(OH)_2$]. The aldehydes used are formaldehyde and furfural [C_4H_3OCHO]. In the uncured and semi-cured condition, phenolic resins are used as adhesives, casting resins, potting compounds, and laminating resins. As molding powders, phenolic resins can found in electrical uses.

POLYAMIDE-IMIDE

Engineering thermoplastic resins produced by the condensation reaction of trimellitic anhydride [$OCC_6H_2C_2O_3$] and various aromatic diamines. Typical applications are found in aerospace, automotive and heavy equipment industries.

Glossary

POLYARYLATES

Engineering thermoplastic resins produced by interfacial polymerization of an aqueous solution of the disodium salt of bisphenol A [$(CH_3)_2C(C_6H_4OH)_2$] with phthalic acid chlorides [$C_6H_4(CO)_2Cl_2$] in methylene chloride (CH_2Cl_2]. The major use of polyarylates is in outdoor lighting.

POLYBUTYLENE

Thermoplastic resins produce via stereospecific Ziegler-Natta polymerization of butene-1 monomer [$CH_2CHCH_2CH_3$]. Typical applications are found in pipe and packaging film.

POLYCARBONATE

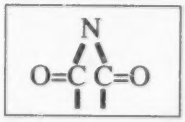
Engineering thermoplastic resins produced by (1) phosgenation of dihydric phenols, usually bisphenol A [$(CH_3)_2C(C_6H_4OH)_2$], (2) ester exchange between diaryl carbonates and dihydric phenols, usually between diphenyl carbonate [$(C_6H_5O)_2CO$] and bisphenol A and (3) interfacial polycondensation of bisphenol A and phosgene [$COCl_2$]. Typical applications are found in glazing, appliances, and electrical uses.

POLYETHYLENE

A family of thermoplastic resins obtained by polymerizing the gas ethylene [C_2H_4]. Low molecular weight polymers of ethylene are fluids used as lubricants; medium weight polymers are waxes miscible with paraffin; and the high molecular weight polymers (i.e. over 6000) are the materials used in the plastics industry. Polymers with densities ranging from about .910 to .925 are called *low density*; those of densities from .926 to .940 are called *medium density*; and those from .941 to .965 and over are called *high density*. The low density types are polymerized at very high pressures and temperatures, and the high density types at relatively low temperature and pressures. A relatively new type called linear low density polyethylene is manufactured through a variety of processes: gas phase, solution, slurry, or high pressure conversion. A high efficiency catalyst system aids in the polymerization of ethylene and allows for lower temperatures and pressures than those required in making conventional low density polyethylene. Copolymers of ethylene with vinyl acetate ethyl acrylate, and acrylic acid are commercially important. Major polyethylene applications can be found in packaging, housewares, toys and communications equipment.

POLYIMIDES

A family of thermoset and thermoplastic resins characterized by repeating imide linkages:



There are four types of aromatic polyimides: (1) condensation products made by the reaction pyromellitic dianhydride (PMDA) [$C_6H_2(C_2O_3)_2$] and aromatic diamines such as 4,4'-diaminodiphenyl ether [$(C_6H_4NH_2)_2O$]; (2) condensation products of 3,4,3',4'-benzophenone tetracarboxylic dianhydride (BTDA) [$(C_6H_5)_2CO(C_2O_3)_2$] and aromatic amines;(3) the reaction of BTDA and a diisocyanate such as 4,4'-methylene-bis(phenylisocyanate) [$OCNC_6H_4CH_2C_6H_4NCO$]; and, (4) a polyimide based on diaminophenylindane and a dicarboxylic andhydride such as carbonyldiphthalic anhydride [$OC_6H_4(CO)_2COC_6H_4(CO)_2$]. Thermoset polyimides are produced in condensation polymers that possess reactive terminal groups capable of subsequent cross-linking through an addition reaction. Typical applications for thermoplastic and thermosetting polyimides are transportation and electronics.

Glossary

POLYPHENYLENE OXIDE, MODIFIED

Engineering thermoplastic resins produced by the oxidative coupling of 2, 6-dimethylphenol [$(CH_3)_2C_6H_3OH$] (xylenol), then blended with impact polystyrene. Typical applications are found in electrical/electronic uses, business machine parts, appliances, and automotive parts.

POLYPHENYLENE SULFIDE

Engineering thermoplastic resins produced by the reaction of p-dichlorobenzene [$C_6H_4Cl_2$] with sodium sulfide [Na_2S]. The major use for polyphenylene sulfide is in electrical/electronic parts and automotive parts.

POLYPROPYLENE

Thermoplastic resins made by polymerizing propylene [CH_3CHCH_2] and in the case of copolymers with monomers, with suitable catalysts, generally aluminum alkyl and titanium tetrachloride mixed with solvents. The monomer unit in polypropylene is asymmetric and can assume two regular geometric arrangements: isotactic, with all methyl groups aligned on the same side of the chain, or syndiotactic, with the methyl groups alternating. All other forms, where this positioning is random, are called atactic. Commerical polypropylene contains 90-97% crystalline or isotactic PP with the remainder being atactic. Most processes remove excess atactic PP. This by-product is used in adhesives, caulks, and cablefilling compounds. Major applications of commerical PP are found in packaging, automotive, appliance and carpeting markets.

POLYSTYRENE

High molecular weight thermoplastic resins produced generally by the free-radical polymerization of styrene monomer [$C_6H_5CHCH_2$] which can be initiated by heating alone but more effectively by heating in the presence of free-radical initiator (such as benzoyl peroxide [$(C_6H_5CO)_2O_2$]. Typical processing techniques are modified mass polymerization or solution polymerization, suspension polymerization, and expandable beads. Major markets for polystyrene are in consumer and institutional products, electrical/electronic uses, and building/ construction.

POLYURETHANES

A large family of polymers based on the reaction product of an organic isocyanate with compounds containing a hydroxyl group. The commonly used isocyanates are toluene diisocyanate (TDI) [$CH_3C_6H_3(NCO)_2$], methylene diphenyl isocyanate (MDI) [$OCNC_6H_4CH_2C_6H_4NCO$], and polymeric isocyanates (PMDI), obtained by the phosgenation of polyamines derived from the condensation of aniline [$C_6H_5NH_2$] with formaldehyde (HCHO]. Polyols (with hydroxyl groups) are macroglycols which are either polyester or polyether based. Polyurethane elastomers and resins take the form of liquid castings systems thermoplastic elastomers and resins, microcellular products, and millible gums. Typical applications are found in the automotive industry. Polyurethane foams are widely used in transportation, furniture, and construction markets.

Glossary

POLYVINYL ACETATE (PVAc) & OTHER VINYLS

Polyvinyl acetate is a thermoplastic resin produced by the polymerization of vinyl acetate monomer [$CH_3COOCHCH_2$] in water producing an emulsion with a solids content of 50-55%. Most polyvinyl acetate emulsions contain co-monomers such as n-butyl acrylate, 2-ethyl hexyl acrylate, ethylene, dibutyl maleate and dibutyl fumarate. Polymerization of vinyl acetate with ethylene also can be used to produce solid vinyl acetate/ethylene copolymers with more than 50% vinyl acetate content. Polyvinyl alcohol (PVOH) is produced by methanolysis or hydrolysis of polyvinyl acetates. The reaction can be controlled to produce any degree of replacement of acetate groups. Co-polymers of replaced acetate groupings and other monomers such as ethylene and acrylate esters are commercially important. *Polyvinyl butyral* (PVB) - made by reacting PVOH with butyraldehyde [$CH_3(CH_2)_2CHO$]. *Polyvinyl formal* - made by condensing formaldehyde [HCHO] in presence of PVOH or by the simultaneous hydrolysis and acetylization of PVAc. *Polyvinylidene chloride* - made by the polymerization of 1,1-dichloroethylene [CH_2CC_{12}]. Typical applications for the above resins are found in adhesives, paints, coatings and finishes, and packaging.

POLYVINYL CHLORIDE

Thermoplastic resins produced by the polymerization of the gas vinyl chloride [CH_2CHC_1]. Under pressure, vinyl chloride becomes liquified and is polymerized by one of four basic processes: suspension, emulsion, bulk, and solution polymerization. The pure polymer is hard, brittle and difficult to process, but it becomes flexible when plasticizers are added. A special class of PVC resin of fine particle size, often called dispersion grade resin, can be dispersed in liquid plasticizers to form plastisols. The addition of a volatile diluent or a solvent to the plastisol produces an organosol. Copolymers with vinyl acetate, vinylidene chloride, and maleate and fumarate esters find commercial application. Major markets for PVC are in building/construction, packaging, consumer and institutional products, and electrical/electronic uses.

STYRENE ACRYLONITRILE

Thermoplastic copolymers of styrene [$C_6H_5CHCH_2$] and acrylonitrile [CH_2CHCN]. SAN resins are random, amorphous copolymers produced by emulsion, suspension, or continuous mass polymerization. Typical uses include automobile instrument lenses and housewares.

STYRENE BUTADIENE LATEXES & OTHER STYRENE COPOLYMERS

Styrene butadiene latexes usually have a resin content of about 50%. The styrene/butadiene ratio varies from 54:46 to 80:20. Most are carboxylated by the use of such acids as maleic [HOOCCHCHCOC], fumaric [HOOCCHCHCOOH], acrylic [$CH_2CHCOOH$], or methacrylic [$CH_2C(CH_3)COOH$]. Two types of *styrene-maleic anhydride* (SMA) [$(COCH)_2O$] are available: SMA copolymers, with and without rubber impact modifier (e.g. DYLARK®) and SMA terpolymer alloys (e.g. CADON®). *K-Resin* ® is a solid styrenebutadiene copolymer resin. Acrylic monomers are also used in conjunction with styrene (or styrene plus other monomers) to produce specialty resins. For example, there are transparent terpolymers of methyl methacrylate, butadiene, and styrene (MBS), and others of acrylonitrile, an acrylic monomer, and styrene (AAS). Ion-exchange resins or divinylbenzene-modified polystyrene are another variation. SB latexes are used in carpet backing and paper coatings. The other styrenics are used in paints, coatings, and floor polishes, plus many other uses.

Glossary

SULFONE POLYMERS

A family of engineering thermoplastic resins characterized by the sulfone ([SO_2] group. *Polysulfone* is made by the reaction of the disodium salt of bisphenol A[$(CH_3)_2C(C_6H_4OH)_2$] with 4,4'-dichlorodiphenyl sulfone(4,4'-DCDPS [$(C_6H_4Cl)_2SO_2$]. *Polyethersulfone* is made by the reaction of 4,4'-DCDPS with potassium hydroxide [KOH]. *Polyphenylsulfone* is similar to the other sulfone polymers. Typical applications for sulfone polymers are found in electrical/electronic uses and automotive parts.

THERMOPLASTIC POLYESTER (SATURATED)

A family of polyesters in which the polyester backbones are saturated and hence unreactive. The most common commercial types are: PET (polyethylene terephthalate) produced by polycondensation of ethylene glycol [CH_2OHCH_2OH] with either dimethyl terephthalate (DMT) [$C_6H_4(COOCH_3)_2$] or terephtalic acid (TPA) [$C_6H_4(COOH_{,2}$]; and PBT (polybutylene terephthalate) produced by the reation of DMT with 1,4 butanediol [$NO(CH_2)_4OH$]. Typical applications are found in packaging, automotive, electrical, and consumer markets.

UREA-FORMALDEHYDE

Formed by the condensation reaction of formaldehyde [HCHO] and urea [$CO(NH_2)_2$]. These thermoset resins are clear water-white syrups or white powered materials which can be dispersed in water to form colorless syrups. They cure at elevated temperatures with appropriate catalysts. Molding powders are made by adding fillers to the uncured syrups, forming a consistency suitable for compression and transfer molding. The liquid and dried resins find extensive used in laminates and chemically-resistant coatings. The molding compounds are formed into rigid electrical and decorative products.

UNSATURATED POLYESTER

Thermosetting resins made by the condensation reaction between difunctional acids and glycols. The resulting polymer is then dissolved in styrene [$C_6H_5CHCH_2$] or other vinyl unsaturated monomer. The structures of the acids and glycols used and their proportions, especially the ratio of the unsaturated versus the saturated acid, and the type and amount of monomer used, are all tailored for each resin to balance economy, processing characteristics, and performance properties. One common formulation is the reaction of maleic anhydride [$(COCH)_2O$], phthalic anhydride [$C_6H_4(CO)_2O$], and propylene glycol [$CH_3CHOHCH_2OH$]. Both dicyclopentadiene [$(C_6H5)_2$] and isophthalic acid [$C_6H_4(COOH)_2$] can be substituted for phthalic anhydride. Vinyl ester resins are linear reaction products of bisphenol A [$(CH_3)_2C(C_6H_4OH)_2$] and epichlorohydrin [CH_2OCHCH_2Cl] that are terminated with an unsaturated acid such as methacrylic acid [$CH_2C(CH_3)COOH$]. Typical applications are found in transportation, appliances, electrical, and construction markets.

Sources: *Chemical Economics Handbook, SRI International, Modern Plastics Encyclopedia*
Whittington's Dictionary, The Condensed Chemical Dictionary

DEFINITIONS OF SELECTED PLASTICS PROPERTIES

ABLATION - The degradation and decomposition of a material caused by high heat friction.

ABRASION RESISTANCE - Ability to resist surface wear.

AGING - The effect, on materials, of exposure to an environment for an interval of time.

ARC RESISTANCE - The total time in seconds that intermittent arc may play across a plastic surface with rendering the surface conductive.

BLEEDING - The diffusion of color out of a plastic part into surrounding surface of part.

BLOCKING - The adhesion between touching layers of plastic, such as that which may develop under pressure during storage or use.

BLOOM - A visible exudation or efflorescence on the surface of a plastic; bloom can be caused by lubricant, plasticizer, etc.

BRITTLE POINT - The highest temperature at which an elastomer fractures in a prescribed impact test procedure.

BRITTLE TEMPERATURE - The lowest temperature at which a plastic material withstands given conditions without failure.

BUCKLING - Crimping of the fibers in a composite material, often occurring in glass-reinforced thermosets due to resin shrinkage during cure.

BULK DENSITY - The density of a molding material in loose form (granular, nodular, etc.) expressed as a ratio of weight to volume.

BULK FACTOR - The ratio of the volume of a molding compound or powdered plastic to the volume of the solid piece produced from it.

COEFFICIENT OF EXPANSION - The fractional change in dimension of a material for a unit change in temperature.

COEFFICIENT OF FRICTION - A measure of the resistance to sliding of one surface in contact with another surface.

COEFFICIENT OF LINEAR EXPANSION - A measure of the change in dimension of an object caused by a change in temperature; specifically measured by the increase in length of an object per unit degree in temperature.

COEFFICIENT OF THERMAL EXPANSION - The change in volume per unit volume produced by a one degree rise in temperature.

COMPRESSIVE STRENGTH - The ability of a material to resist a force that tends to crush.

Glossary

CORROSION RESISTANCE - The ability of a material to withstand contact with ambient natural factors or those of a particular artificially created atmosphere.

CRACK - An actual separation of molded material, visible on opposite surfaces of the part, and extending through the thickness; a fracture.

CRAZING - Fine cracks which may extend in a network on or under the surface of a plastic material.

CREEP - The change in dimension of a plastic under load over a period of time, not including the initial instantaneous elastic deformation.

CROSS-LINKING - Applied to polymer molecules, the setting-up of chemical links between the molecular chains. When extensive, as in most thermosetting resins, cross-linking makes one infusible supermolecule of all the chains.

DEFLECTION TEMPERATURE UNDER LOAD - The temperature at which a simple beam has deflected a given amount under load (formerly called heat distortion temperature).

DEFORMATION - Any change of form or shape in a body; the linear change of dimension of a body in a given direction produced by the action of external forces.

DEGRADATION - A deleterious change in the chemical structure of a plastic.

DETERIORATION - A permanent change in the physical properties of a plastic evidenced by impairment of these properties.

DIMENSIONAL STABILITY - Ability of a plastic part to retain the precise shape to which it was molded, cast, or otherwise fabricated.

DISCOLORATION - Any change from an initial color possessed by a plastic; a lack of uniformity in color where color should be uniform over the whole area of a plastic object.

ELASTICITY - That property of plastics materials by virtue of which they tend to recover their original size and shape after deformation.

ELASTOMERIC - The property of a material which at room temperature can be stretched under low stress to at least twice its original length and, upon immediate release of the stress, will return with force to its approximate original length.

ELECTRICAL STRENGTH [DIELECTRIC STRENGTH] - That property of an insulating material which enables it to withstand electric stress; the highest electric stress which an insulating material can withstand for a specificed time without the occurrence of electrical breakdown by any path through its bulk.

ELONGATION - Deformation caused by stretch; the fractional increase in length of a material stressed in tension.

ENVIRONMENTAL STRESS CRACKING - The susceptibility of a thermoplastic resin to crack or craze when in the presence of surface active agents or other environments.

Glossary

EXTENSIBILITY - The ability of a material to extend or elongate upon application of sufficient force, expressed as a percent of the original length.

EXUDATION - The formation in liquid form a plasticizer on the surface of a plasticized resin.

FADING - Any lightening of an initial color possessed by a plastic; measured by accelerating the process by subjecting the plastic to high intensity ultraviolet rays of approximately the same wave length as those found in sunlight.

FATIGUE - The failure or decay of mechanical properties after repeated applications of stress.

FLAMMABILITY - Measure of the extent to which a material will support combustion.

FLEX LIFE - The time of heat-aging that an insulating material can withstand before failure when bent around a specific radius (used to evaluate thermal endurance).

FLEXURAL STRENGTH - The resistance of a material to being broken by bending stresses.

FLOW MARKS - Wavy surface appearance of an object molded from thermoplastic resins, caused by improper flow of the resin into the mold.

GEL POINT - The stage at which a liquid begins to exhibit pseudoelastic properties. Also known as "gel-time."

GLASS TRANSITION TEMPERATURE - The center of the temperature range in which a noncrystalline solid changes from being glass-brittle to being viscous.

GLOSS - Brightness or luster of a plastic resulting from a smooth surface.

HAZE - Cloudy appearance within, or on the surface, of a plastic.

HEAT DISTORTION POINT - The temperature at which a standard test bar deflects under a stated load.

HEAT RESISTANCE - The property or ability of plastics and elastomers to resist the deteriorating effects of elevated temperatures.

HYDROLYSIS - Chemical decomposition of a substance involving the addition of water.

HYDROPHILIC - Capable of absorbing water.

HYDROPHOBIC - Capable of repelling water.

HYGROSCOPIC - Capable of adsorbing and retaining atmospheric moisture.

IMPACT STRENGTH - The ability of a material to withstand shock loading.

LACK OF FILLOUT - An area, occurring usually at the edge of a laminated plastic, where the reinforcement has not been wetted with resin.

Glossary

MELT INDEX - The amount in grams, of a thermoplastic resin which can be forced through a 0.0825 inch orifice when subjected to 2160 grams force in 10 minutes.

MELTING POINT - The temperature at which a resin changes from a solid to a liquid.

MELT STRENGTH - The strength of a plastic while in the molten state.

MIGRATION - The transfer of a material from a plastic body to other contacting solids.

MOISTURE ABSORPTION - The pick-up of water vapor from air by a material. It relates only to vapor withdrawn from the air by a material and must be distinguished from water absorption, which is the gain in weight due to the take-up of water by immersion.

MOTTLE - The desired or accidental mixture of colors or shades of a color giving more or less distinct or complicated patterns or specks, spots, or streaks of color; any irregular imperfections on the surface.

NECKING - The localized reduction in cross-section which may occur in a material under tensile stress.

OPALESCENCE - The limited clarity of vision through a sheet of transparent plastic at any angle, because of diffusion within or on the surface of the plastic.

OPTICAL DISTORTION - Any apparent alteration of the geometric pattern of an object when seen through a plastic or as reflection from a plastic surface.

OXIDATION - The chemical reaction involving the process of combining with oxygen to form an oxide; the deterioration of an adhesive film due to atmospheric exposure; the break down of a hot melt adhesive due to prolonged heating and oxide formation.

PIT - Small regular or irregular crater in the surface of a plastic, usually with width approximately of the same order of magnitude as its depth.

PLASTICITY - A property of plastics which allows the material to be deformed continuously and permanently without rupture upon the application of a force that exceeds the yield value of the material. (The opposite of "elasticity.").

SHEARING - Breaking caused by the action of equal and opposed forces, located in the same plane.

SPECIFIC GRAVITY - The ratio of the weight of any volume of a substance to the weight of an equal volume of another substance taken as standard at a constant or stated temperature. Solids and liquids are usually compared.

SPECIFIC HEAT - The quantity of heat required to raise the temperature of a unit mass of a substance one (1) degree under specified conditions.

STRESS-CRACK- External or internal cracks in a plastic caused by tensile stresses less than that of its short-time mechanical strength.

SWEATING - Exudation of small drops of liquid, usually a plasticizer or softener, on the surface of a plastic part.

Glossary

SWELL - A dimensional increase caused by exposure to liquids and/or vapors.

TEAR RESISTANCE - The force required to tear completely across a notched specimen tested according to prescribed procedures, expressed in pounds per inch of specimen thickness.

TENSILE STRENGTH OR STRESS - The maximum tensile load per unit area of original cross section, within the gage boundaries, sustained by the specimen during a tension test.

THERMAL CONDUCTIVITY -Ability of a material to conduct heat.

THERMOELASTICITY - Rubber-like elasticity exhibited by a rigid plastic and resulting from an increase of temperature.

THERMOPLASTICITY - The ability of material to be deformed without breaking with a relatively fast flow, when (at a suitable temperature) this material is properly stressed.

TUNNELING - A condition occuring in incompletely bonded laminates, characterized by release of longitudinal portions of the substrate and deformation of these portions to form tunnel-like structures.

VISCOSITY- The property of resistance to flow exhibited within the body of a material, expressed in terms of relationship between applied shearing stress and resulting rate of strain in shear.

WEATHERING - The exposure of plastics outdoors.

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Business Consulting Groups and Publishers

Business Communications Co., Inc. - 25 Van Zant St., Norwalk, CT 06855 - 203/853-4266
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Eldib Engineering & Research, Inc. - 613 Springfield Ave., Berkeley Heights, NJ 07922 - 201/464-2244
Frost & Sullivan, Inc. - 106 Fulton St., New York, NY 10038 - 212/233-1080
Charles H. Kline & Co. - 330 Passaic Ave., Fairfield, NJ 07006 - 201/227-6262
R.M. Kossoff & Associates, Inc. - 10 Rockefeller Plaza, New York, NY 10020 - 212/246-4035
Arthur D. Little, Inc. - 25 Acorn Park, Cambridge, MA 02140 - 617/864-5770
Margolis Marketing & Research Co. - 232 Madison Ave., Suite 905, New York, NY 10016-2978 - 212/685-1278
Market Search, Inc. - 2727 Holland Sylvania Rd., Toledo, OH 43615 - 419/535-7899
Morton Research Coporation - 28 Merrick Ave., Merrick, NY 11566 - 516/378-1066
Noyes Data Corp. - Mill Road at Grand Ave., Park Ridge,NJ 07656 - 201/391-8484
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Peter Sherwood Associates, Inc. - 20 Haarlem Avel, White Plains, NY 10603 - 914/761-3033
Skiest Laboratories, Inc. - 375 Route 10, Whippany, NJ 0781 - 201/515-2020
Springborn Group - 10 Springborn Cir., Enfield, CT 06082 - 203/749-8371
SRI International - 333 Ravenswood Ave., Menlo Park, CA 94025 - 415/326-6200
The Target Group - 1000 Harston Lane, Philadelphia, PA 19118 - 215/233-4083
Technomic Consultants, Inc. - 300 South Riverside Plaza, Chicago, IL 60606 - 312/876-0004
Technomic Publishing Co. - 851 New Holland Ave., Box 3535, Lancaster, PA 17604 - 717/291-5609

Government Publications

Annual Survey of Manufacturers - Bureau of the Census
Census of Manufacturers - Bureau of the Census
Current Industrial Reports - Bureau of the Census
Foreign Trade Reports - FT 135 (imports), FT 410 (exports) - Bureau of the Census
Guide to Census Bureau Data Files and Special Tabulations - Bureau of the Census
Guide to Foreign Trade Statistics - Bureau of the Census
Producer Price Indexes - Bureau of Labor Statistics
Standard Industrial Classification Manual - Office of Management and Budget
Statistical Abstract of the U.S. - Department of Commerce
Statistical Services of the U.S. Government - Office Management and Budget
Synthetic Organic Chemicals - International Trade Commission
U.S. Industrial Outlook - Department of Commerce

Newspapers

Chemical Marketing Reporter - 100 Church St., New York, NY 10007 - 212/732-9820
Journal of Commerce - 110 Wall St., New York, NY 10005 - 212/425-1616
Rubber & Plastics News - 1725 Merrinan Rd., Suite 300, Akron, OH 44313 - 216/836-9180

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Chemical Marketing Research Assn. - 139 Chestnut Ave., Staten Island, NY 10305 - 718/727-0550
Chemical Specialities Manufacturers Assn. - 1001 Connecticut Ave., NW, Washington, D.C. 20036 - 202/223-8891
Composite Can & Tube Institute - 1813 N St., NW, Suite T-10, Washington, D.C. 20036 - 202/223-4840
Drug, Chemical & Allied Trades Assn. - 42-40 Bell Blvd., Suite 604, Bayside, NY 11361 - 718/229-8891
Dry Color Manufacturers Assn. - Sutie 202, 206 N. Washington St., P.O. Box 20839, Alexandria, VA 22314 - 703/684-4044
Flexible Packaging Assn. - Suite 500, 1090 Vermont Ave., NW, Washington, D.C. 20005 - 202/842-3880
INDA - 1700 Broadway, New York, NY 10019 - 212/582-8401
International Institute of Synethetic Rubber Producers - 2077 S. Gessner Rd., Suite 133, Houston, TX 77063 - 713/783-7511
International Isocyanate Institute - 119 Cherry Hill Rd., Parsipanny, NJ 07054 - 201/263-7517
National Paint & Coatings Assn. - 1500 Rhode Island Ave. NW, Washington, D.C. 20005 - 202/462-6272
Polyurethane Manufacturers Assn. - 1500 K St., NW, Washington, D.C. 20005 - 202/682-1338
Society of Plastics Engineers - 14 Fairfield Drive, Brookfield Center, CT 06805 - 203/775-0471
Society of the Plastics Industry-Canada - 1262 Don Mills Rd., Suite 104, Don Mills, Ontario M3B2W7 - 416/449-3444
Synthetic Organic Chemical Manufacturers Assn. - 1330 Connecticut Ave., NW, Suite 300, Washington, D.C. - 202/659-0060

Trade Publications

Canadian Plastics - 1450 Don Mills Road, Ontario M3B2X7 - 416/445-6641
Chemical Engineering - 1221 Ave. of the Americas, New York, NY 10020 - 212/512-3198
Chemical & Engineering News - 1155 16th St., NW, Washington, D.C. 20036 - 202/872-4600
Chemical Week - 1221 Ave. of the Americas, New York, NY 10020 - 212/512-2292
Material Engineering - 1100 Superior Ave., Cleveland, OH 44114 - 216/696-7000
Modern Plastics - 1221 Ave. of the Americas, New York, NY 10020 - 212/512-6243
Packaging Digest - 122 East 42nd St., New York, NY 10168 - 212/867-9191
Plastics Compounding - 1129 East 17th Ave., Denver, CO 80218 - 303/832-1022
Plastics Connection - P.O. Box 814, Amherst, MA 01004 - 413/549-5020
Plastics Design Forum - 1129 East 17th Ave., Denver, CO 80218 - 303/832-1022
Plastics Design & Processing - 17730 Peterson Rd., Libertyville, IL 60048 - 312/362-8711
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MONTHLY STATISTICAL REPORT

THERMOSETTING & THERMOPLASTIC RESINS

This publication is the only source of monthly detailed data on production and sales & use (captive) available. A sample of the report follows on the next page. The following materials are included:

Epoxy	Polypropylene	Other Styrene-based Polymers
Polyester	ABS	Nylon
Urea	SAN	PVC
Melamine	Polystyrene	Polyvinyl Acetate
Phenolic	Styrene Butadiene Latexes	Polyvinyl Alcohol
Polyethylene	Other Styrene-based Latexes	Thermoplastic Polyester

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MONTHLY STATISTICAL REPORT
THE SOCIETY OF PLASTICS INDUSTRY, INC.
(In thousands of pounds, dry weight basis)

THERMOSET RESINS

DECEMBER 1980

RESIN KIND & USE	SALES & CAPTIVE USE						PRODUCTION					
	DECEMBER			YEAR-TO-DATE			DECEMBER			YEAR-TO-DATE		
	1980	1979	% Change	1980	1979	% Change	1980	1979	% Change	1980	1979	% Change
EPOXY (UNMODIFIED) RESINS, TOTAL	30,709	25,639	+ 19.8	318,756R	331,970	-4.0	26,491	24,829	+ 6.7	315,039R	361,077	-12.8
Total Exports	3,732	3,496	+6.8	35,547	35,730	-0.5						
Total Domestic	26,977	22,143	+12.8	283,209R	296,240	-4.4						
Bonding & Adhesives	1,931	1,431	+34.9	17,742R	17,454	+1.7						
Flooring, Paving & Exposed Aggregate	1,886	1,481	+27.3	19,231R	19,583	-1.8						
Protective Coatings	13,417	9,648	+39.1	137,308R	146,137	-6.0						
Fiber Reinforced Laminates & Composites	5,164	4,785	+7.9	62,690R	60,268	+4.0						
Tooling, Casting & Molding Resins	2,749	2,417	+13.7	25,664R	30,940	-17.1						
All Other Uses	1,830	2,381	-23.1	20,574R	21,858	-5.9						
POLYESTER (UNSATURATED) RESINS, TOTAL	75,749	76,020	-0.4	921,169R	1,151,581	-20.0	76,524	78,733	-2.8	925,947R	1,147,174	-19.3
General Purpose Resins							66,503	68,719	-3.2	805,583R	1,010,750	-20.3
Fire Retardant Resins							2,757	2,550	+8.1	28,739	32,035	-10.3
Chemical Resistant Resins							7,264	7,464	-2.7	91,625 R	104,389	-12.2
Isophthalic Resins							3,830	4,917	-22.1	52,437R	63,158	-17.0
All Other Resins	903	841	+7.4	11,254	14,250	-22.5	3,434	2,547	+34.8	39,188R	41,231	-5.0
Total Exports	74,846	75,179	-0.4	909,915R	1,137,061	-20.0						
Total Domestic	59,069	58,428	+1.1	709,229R	905,949	-21.7						
Reinforced Plastics, Total	15,777	16,751	-5.8	200,686R	231,112	-13.2						
Non-Reinforced Plastics, Total	719,992	666,312	+8.1	7,467,465R	7,814,845	-4.4						
LOW-DENSITY POLYETHYLENE 0.940 & BELOW, TOTAL	109,576	65,000	+68.6	1,147,442R	897,575	+27.8	675,113	650,391	+3.8	7,290,727R	7,793,233	-6.4
Total Exports	610,416	65,000	+68.6	1,147,442R	897,575	+27.8						
Total Domestic	610,416	601,312	+1.5	6,320,023R	6,917,270	-8.6						
Film (12 Mils & Below)	392,242	383,360	+2.3	4,003749	4,363,250	-8.2						
Sheet (Over 12 Mils)	921	1,930	-52.3	18,176	25,825	-29.6						
Injection Molding	46,555	57,100	-18.5	519,294R	649,975	-20.1						
Wire & Cable	20,042	34,572	-42.0	335,403	424,139	-20.9						
Extrusion Coating	44,772	41,001	+9.2	517,406R	539,098	-4.0						
Blow Molding	5,129	4,786	+7.2	65,453R	59,524	+10.0						
Pipe & Conduit	2,660	2,293	+16.0	21,768R	32,718	-33.5						
Other Extruded Products	4,244	5,140	-17.4	56,018R	79,614	-29.6						
All Other Uses	93,851	71,130	+31.9	782,756R	743,127	+5.3						
HIGH-DENSITY POLYETHYLENE ABOVE 0.940, TOTAL	413,377	394,243	+4.9	4,393,038R	4,893,243	-10.2	407,174	419,864	-3.0	4,405,021	5,009,839	-12.1
Total Exports	61,114	54,188	+12.8	526,438R	608,654	-13.5						
Total Domestic	352,263	340,055	+3.8	3,866,600	4,284,589	-9.8						
Film (12 Mils & bBelow)	21,622	14,714	+46.9	201,086	212,399	-5.3						
Sheet (Over 12 Mils)	7,921	4,541	+74.4	54,937	65,520	-16.2						
Injection Molding	89,601	84,541	+6.0	937,964	1,073,724	-12.6						
Wire & Cable	6,285	7,074	-11.2	105,555	125,921	-16.2						
Extrusion Coating	3,213	2,038	+57.7	27,565	30,242	-8.9						
Blow Molding	138,168	139,521	-1.0	1,573,140	1,724,076	-8.8						
Pipe & conduit	30,468	25,135	+21.2	368,352	400,395	-8.0						
Other Extruded Products	1,703	2,120	-19.7	24,250	18,931	+28.1						
All Other Uses	53,282	60,371	-11.7	573,751	633,381	-9.4						

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